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From L'Illustration

An armored railway battery in France equipped with 19 C. M. naval guns

CRUISERS OF THE RAILS [See page 215

An Important Biological Problem*

The Significance of Essences and Pigments

By Jean Dufrénoy, Assistant at the Biologic Station at Arcachon

LIFE has for its result the production of stable compounds[1], incapable of serving for the elaboration of new living matter. Their accumulation in the midst of the cytoplasm causes senility and natural death; in order to defend itself from auto-intoxication the living creature must either eliminate them or isolate them.

The two best known and most widely found forms of these catabolic products, the *essences* and the *pigments*, both have the same biologic significance.

Their production bears witness to the same ecologic, physiologic and pathologic causes: the more intense radiation experienced in Alpine regions gives the plants there found at once a livelier coloring and a stronger odor.[2]

Products of the reabsorption of cytological and histological elements, the essences and the pigments, are the ultimate products of series wherein nitrogenous compounds, fats, tannins, starch, hemicelluloses, pectoses, figure as primary or intermediate terms:

Fatty acids (by oxidation) ..... resins[3]
Cholesterines ..... resins[4]
Hemicelluloses ..... resins[4]
Celluloses, Pectoses ..... resins[5]
Starch, Amylopectine, Erythrodextrine, Achroodextrine ..... resins[6] / pigments
Glucose (in presence of oxidases) ... Anthocyanines[7]
Tannins? ..... Anthocyanines[7] / resins[8]

Essence-bearing plants are not subject to autumnal reddening of the leaves.

Essences and pigments mutually replace each other in pathological reactions: the resinous cankers and cecidia of the Gymnosperms correspond to the colored cankers and cecidia of the deciduous trees.

ESSENCES

§ 1. *Resinous Secretion.*

The *resinous secretion* is a result of complex phenomena: 1. *Elaboration*, in the heart of the cytoplasm, of the products of disassimilation; 2. *Emigration* and ulterior *transformations* of these essential oils in the *secretory cells* differentiated from the physiologic and morphologic double point of view; 3. *Elimination* to the outside, or *accumulation* in internal lacunae (pockets or canals) of these transformed products.

§ 2. *Secretory Epiderma.*

The unicellular organism expels its catabolic products[9] directly into the external environment.

The internal cells of the higher plants must expel their secretions into the midst of the adjacent cells. Only the epidermic cells, which can expel them to the outside, never saturate their cytoplasm with them, and always remain capable of receiving them by osmosis from adjacent cells.

In many essence bearing plants the epidermic cells are excretory.[10]

But when the epidermis cutinises itself, becomes impermeable, the internal cells have no place to pour out their excretions except the intercellular meata.

§ 3. *Resiniferous Pockets and Canals.*

Here and there the resinification of their median camella permits certain cells to draw apart; by their free surface they eliminate their secretions, and rendered capable of constantly receiving the secretions of adjacent tissues, they assume a role of filtration and the elaboration of residues; they become excretory cells.

The secretory cells are cells of very active metabolism which very soon acquire the habit of expelling their secretions into the intercellular spaces.

By preventing auto-intoxication they retain the faculty of active self-multiplication, while enlarging the central lacuna into which they pour their secretions.[11]

But the labor of excretion which this faculty imposes upon them causes, when excessive, their *hypertrophy*,[12] and then their *resinous dissolution*.[13]

§ 4. *Resinoses of Defense.*

The number of resiniferous pockets and canals[14] is determined by the catabolism of the tissues, and the resinification on the spot of the cells of the parenchyma is a mode of defense for tissues which have been wounded[15] or attacked by parasites.[16]

The essence bearing plants (*Umbelliferae, Cruciferae*) are resistant to the Dodder (Mirande), and the letter, when it attacks the alkaloid bearing plants (Solencae) secretes in its suckers an oily defensive substance.

"Other things being equal, the plants which have neither taste nor perfume do not offer so long a resistance as those whose odor is strong and which contains balsamic or essential oils. Lettuce, wheat, barley, etc., live but a year. Hyssop, thyme, balm-mint, wormwood, etc., can resist for two years or even longer."[17]

The deciduous plants are constrained to adopt periods of latent life (winter repose) and their assimilative apparatus is caducous.[18] The gymnosperms defended from auto-intoxication by their secretory apparatus, remain in constant vegetative activity and their needles are perennial.[19]

PIGMENTS

Pigments are colored products of disassimilation, that is, capable of absorbing luminous radiations. They acquire thereby a considerable degree of importance in metabolism, since it is by means of light that the living creature acquires this power of achieving the synthesis of its own substance.

§ 1. *Pigments and Photochemical Energy.*

The hydrocarbons of plants and their nitrogenous and fatty matters are the result, not of biological, but of photochemical syntheses. The synthesis of nitrates, the biological result of the symbiosis of the microorganisms of the soil with the algae or the higher plants, is obtained directly by the action of electric emanations.

The synthesis of the hydrates of carbon, long regarded as absolutely dependent upon the activity of the green plants, has been accomplished directly by Spoehr, starting with the carbonic gas of the atmosphere under the sole influence of ultra-violet light.[20]

If the chlorophyl is not the specific agent of the assimilation of carbon, does it remain the peculiar factor in the plant of the assimilation of carbon and nitrogen, as was the general view of physiologists during the last century? In that case we ought to, in the same species, find it the more abundant the less intense the light received by the plants, since, having a less amount of energy at their disposal, they would have to use a larger proportion of it.

But it is the contrary which we find to be true. Moreover, in the same conditions of temperature, of light, and of the composition of the atmosphere, *the quantity of carbonic gas assimilated by an organ is not proportional to the quantity of chlorophyl which it contains* (Willstätter, 1915).[21]

In normal leaves of the same age, and all rich in chlorophyl, there is indeed a rough proportionality between the chlorophyl content and assimilation. But in the leaves of the same plant the coefficient of assimilation[22] varies greatly with the age; while the chlorophyl becomes constantly more abundant the assimilation increases relatively little at the beginning and decreases at the end (table I).

TABLE I

Temp. 25° – 5% CO^2 – 48,000 lux (Willstätter)

LINDEN	Chlorophyl Content	CO^2 (assimil. per hr.)	CA
Light green young leaves	5.2 mg	74 mg	14.2
Deep green old leaves	22.5 mg	148 mg	6.6
TAXUS BACCATA			
Young Branch	27.6 mg	134 mg	4.7
Year old Branch	47.5 mg	102 mg	2.1

In short, the leaves poor in chlorophyl (containing only 15 to 3 per cent. of the content of normal leaves of the same variety) assimilate as much *in a moderate light* as the leaves rich in chlorophyl (table II).

The utilization of luminous radiations is not the peculiar prerogative of chlorophyl. "The products of disintegration which color the tissues of plants red or blue play the same role with respect to solar light as does chlorophyl or the pigments of the algae,"[23] and the pigments of animals, those of the human skin in particular, are perhaps capable of transforming it into energy utilizable by the organisms.[24] However, in man, as in the plant, the significance of photochemical reactions still escapes us; heliotherapy has preceded heliology, says Dr. F. Lalesque.

We are scarcely better informed upon the pigmentary utilization of calorific energy.

§ 2. *Pigments and Calorific Energy.*

The living creature is a thermal machine capable of liberating, by slow oxidations, the potential energy of various substances, which it makes use of as food, but

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*Translated for THE SCIENTIFIC AMERICAN SUPPLEMENT from *Revue Generale des Sciences.*

[1] We know that these waste products are always compounds of a closed chain, such as that of turpenture or pinene.

[2] E. Gain: Floral Regions. *Geog. bot.*, vol. I., p. 56. Nancy, 1908.

[3] Mazé, cited by André: *Chem. Agric.*, p. 304.

[4] Tschirch: The Bases of a Physiol. Chem. of Plant Secretions. *Rev. Gen. d. Sc.*, vol. XVIII., p. 750; 1907.

[5] R. Molinery and J. Dufrénoy: The Resources of Defense. *Conc. Medic.*, in press.

[6] The relative abundance of the amyloleucites and the oleoresins forms the object of an interesting physiologic balancing: "The oleo-resinous drops, specially abundant in summer in the needles of the pine (maritime), undergo fluctuations inverse to those of the starch." (Barque: *P. V. Soc. linn. Bx.*, p. 71, 1910.) We have demonstrated that the condition of the starch in the resinified cells is quite variable. In a few rare cases we find in the exuded resin non-altered amyloleucites. But most generally their unequal colorability by the gram shows that, when the resinification progresses, the starch (colorable blue) is successively transformed into soluble starch and amylopectine (colorable violet), into erythrodextrine (colorable wine red) and then into achroodextrine (non-colorable). In contact with these uncolored grains we see the birth and enlargement of the resinous droplets, soluble in alcohol and in xylol.

[7] Mirande: Upon the Origin of Anthocyanine Deduced from the Observation of Certain Parasites of Leaves (*C. R. Ac. Sc.*, 1907); and R. Combes: Relation Between the Hydrocarbon Compounds and the Formation of the Anthocyanines (*Ann. Sc. Nat. Bot.*, 1909). We have demonstrated the disappearance of starch and the accumulation of tannins in the reddening leaves of buckwheat plants too well irrigated: Green leaves—Starch abundant, tannin absent. Red leaves—Starch absent, tannin abundant. Yellowing leaves—Starch abundant.

[8] Bastin, Trimble, Uler, J. Dufrénoy.

[9] G. Bohn: Infl. of External Milieu Upon the Egg. *Rev. Gen. d. Sc.*, 1901, p. 245.

[10] In the scale leaves of the buds of the pine the resin filters through the epidermis, whose cells, elongated, moreover, allow an abundant resin to form in drops. The young leaves of pine still possess some secretory epidermic cells, upon their edges; but the epidermis of the needles is everywhere sclerified and impermeable.

[11] Schizogenous Enlargement of Pockets and Canals. H. J. De Cordemoy: The Gum and Resin Bearing Plants. *Encyc. Sc.*, O. Doin, Paris, 1910, p. 191.

[12] Giant secretory cells of pine needles which are teratologic or parasitically affected by the rusts (*Cronartium* and *Melampsora*), or by rubigo.

[13] Normal lysigenous enlargement of the canals of the wood of pine.

[14] Supernumerary Schizogenous Canals of needles of the maritime pine parasitically affected by the *Hypoderina pinastri*—cicatricial swellings of cankers and wounds (borders of brown rust or fire-blast).

[15] In the stem of maritime pines the wounds of caries cause the resinification of the medullary rays, and, in places, the resinification of the median lamella of two rows of ligneous fibers, to form transverse canals, which brigg the longitudinal resiniferous canals into relation with each other and with the caries. These canals will be described in detail by Dr. F. Lalesque in his *"Monogr. Scient. et Médic. d'Arcachon."*

[16] To limit the spots of rubigo, the needles of the maritime pine resinify one or two rows of cells to form a barrier to the invading march of the *Hypoderma*, against which its filaments abut and climb, without the power to penetrate it.

[17] Hufeland: The Art of Prolonging Life, cited by Hubert: Plants (*Merv. de la Nat.*).

[18] The fall of the leaves is not due to the rigors of winter; even in the gigantic forests of the coast of Brazil, where vegetation is maintained in continual activity by the heat and the humidity, there are trees which annually lose all their leaves at the same time (A. St. Hilaire: *Lec. de Bot.*).

[19] The leaves of the Larch, which have no secretory apparatus, are caducous.

[20] A solution of carbonic anhydride and of potassium bicarbonate, exposed to the light of a quartz mercury lamp, is reduced; formic acid is formed, then, by condensation, a complex saccharine compound, analogous to formose, which reduces Fehling's solution, and is accepted by algae, in the dark, as their sole carbon-containing aliment. (H. A. Spoehr: Studies in Photosynthesis, p. 65, Carnegie Inst. of Washington, 1915.)

[21] After Jörgensen and W. Stiles: Carbon Assimilation . . . on the Pigments of the Green Leaf. *The New Phytologist*, vol. XV., No. 8; October, 1916.

[22] C. A. = $\frac{CO_2 \text{ assimilated per hr.}}{\text{chlorophyl content}}$, the experimental conditions being such that the assimilation of a normal leaf cannot be augmented either by a greater concentration of CO_2 (here 5%), or by a more intense illumination (here flux of 48,000 to 130,000 lux furnished by an Osram lamp of 3,000-candle power placed at 25.15 centimeters).

[23] MacDougal: Aridity and Evolution. *Plant World*, p. 220, October, 1909.

[24] Nogier: *Av. Médic.*, cited by R. Molinéry: Guide to Physiotherapy, 1917.

particularly capable of directly utilizing the calorific energy of light. In sunlight plants absorb a larger proportion of the incident calorific energy than do inert bodies; they radiate less heat. The air becomes less heated above ground covered with vegetation than above bare earth. And the richer in chlorophyl plants are

TABLE II

Elm 5% CO^2, 3,000 c.p. lamp 35 cm. distant (24,000 lux) (Willstätter)

	Temp.	Chlorophyl (mg)	CO^2 assim. pr. hr. (mg)	CO^2 assim. pr. m^2 (gm)	CA.
Yellow leaves (surface 321 cm^2)	25°	0.95	75	2.3	79
	15°	0.95	50	1.7	59
Green leaves (surface 421 cm^2)	25°	13.00	89	2.1	6.9
	15°	13.00	59	1.4	4.5

the less heat they lose by radiation the less do they heat the air above them.

RADIATION AND PIGMENTATION

At 10° C. above—	Temperature of air in sunshine
Bare rocky ground	26° C.
Thatched roof	25° C.
New mown rye	24.5° C.
Matured rye	24° C.
Buckwheat in flower	23.5° C.
Green meadow, rich in chlorophyl	23° C.

The green leaves are those which become most heated in the sun.

LEAVES

	Temperature
Green	t°
Green, rusted[23]	t—0.5
Yellow (sickly)	t—1.
Red (autumnal)	t—2.
Green spotted with red[24]	t—2.
Yellow spotted with red[25]	t—2.5

But while they absorb more heat than inert bodies plants become less heated in the sun.[27] This is because the total amount of caloric energy absorbed by inert bodies serves to raise their temperature, while that absorbed by plants must be partially transformed into chemical energy to serve the process of life.[28]

§ 3. *Pigments and Radiant Energy.*

Light is not merely an agent of reduction or of synthesis. Its effects of ionization influence the respiration, the growth and the differentiation of the tissues.[29]

Light dissociates the oleo-resins[30] and the vegetable acids accumulated during the night.[31] It rapidly kills bacteria in cultures exposed to sunlight, and causes the diatoms on the surface of the sea to disappear. Only those organisms resist its destructive action which shelter their living substance by a screen of pigments.

The chlorophyl is a screen, as much, and perhaps even more than it is a photochemical reagent; the leaves poor in chlorophyl cannot support without lesions so intense an illumination as the green leaves can bear (Willstätter).

The fungi shelter themselves in the shade of the chlorophyl of the algae (lichens) or of the higher plants; here they substitute,[32] or sometimes add, a screen of their own pigments, or of the colored reactions of the host.[33]

The germinative cell surrounds itself, in the grain of pollen, with a vegetative cell colored yellow by carotin in order to be protected during its aerial voyages,[34] and the embryo is protected in the seed by the *chromatic zone* of the teguments.

§ 4. *Radiation and Pigmentation.*

In any given species pigmentation is a function of the illumination. Willstätter has demonstrated it experimentally.

TABLE III

The turning green of pale and sickly leaves of the *phaseolus vulgaris*.

Temp. 25° Atmosphere 5% CO^2 Luminous Intensity (48,000 lux)

Light	Color	Wt. of Leaf (gm)	Chlorophyl Content (mg)	CO^2 assim. pr. hr. (gm)
Non-illuminated previously illuminated 6 hrs.	yellow	5.	<0.1	0.007
" 2 days	greenish	4.4	0.3	0.040
" 4 days	greenish	5.	4.0	0.096
"	green	5.	7.8	0.104

It is the light which makes leaves turn green; the quantity of chlorophyl which they contain and the development of their *palissadic* layers depends upon the illumination.

It is light which causes the colors of flowers to appear; the alpine plants, subjected to an intense radiation, have colors far more brilliant than do the plants of the plains. With the cause the coloration disappears; the flowers of the trefoils and the vetches, red in the sun-bright pastures of the mountains, are white in the shade of the beeches; and between the limits of these two positions we may observe intermediate ones, in which the rather scanty pigment becomes localized (table IV).

Pathologic colorations do not appear in galls except on the side exposed to the sun.

§ 5. *The Evolution of Pigments.*

From the beginning living tissues have been obliged to retain their catabolic pigments as photochemical screens, capable of absorbing luminous energy to put it at the disposal of the enzymes under a favorable form, and in the optimum quantity.

TABLE IV

Radiation and pigmentation (vetches and trefoils or clover).

	POSITIONS			
	Rocky Areas Strong sun and light reflected from ground	MEADOWS (Sunny)	UNDER THE BEECHES (Penumbra)	UNDER THE BEECHES (Shadow)
Flowers	red	red	pink, spotted	white or absent
Leaves	dark green	green	light green	yellowish green
Palisade assises	3 superior 3 inferior	3 superior		1 superior row little differentiated
Assises of lacunous parenchyma	lacking	3-inferior		5 rows

At that time plants were pigmented in all their parts, which were all similar both morphologically and physiologically, and endowed in common with the functions of defense, of assimilation and of reproduction all at once.

Then, in consequence of progressive sterilization, due to the division of physiologic labor, the majority of the plant members become sterilized.[35] Specially consecrated to assimilation they have preserved the chlorophyl pigment alone, that one which possesses in the highest degree the power of absorbing luminous radiations (MacDougal). The members which have remained fertile have developed in various directions, and adjacent organs, floral, have alone retained some of the ancestral pigments.[36]

In the animal kingdom adaptation to parasitic life—that is to say, the habit of utilizing, in place of solar energy, the reserve energy stored up by plants—has caused general depigmentation.

The majority of animals excrete their catabolic pigments (bilirubin, etc.) without utilizing them. Some pigments in animals, however, remain connected either with essential physiologic functions (hemoglobin, retinien purple), or with particular means of defense.[37]

§ 6. *Pigmentations of Defense.*

The accumulation of colored pigments in the chitinous covering of the Arthropods, in the epidermis of the vertebrates, often has for its object the mimicking of the exterior environment; but it also protects the individual against an excess of radiation.

The depigmented tritons of the subterranean lakes of Carmola cannot support either light or the feeblest emanations of radiance (Régnard).

According to our mountain folk the red cows better support the ardor of the sun than the white ones, and Swiss breeders attach great importance to a coat spotted with red.

Among horses or sheep whose photochemical sensitiveness has been excited by the ingestion of fluorescent principles contained in certain kinds of St. John's wort, found in the Mediterranean country,[38] tumors appear only on the white parts of the skin. The pigmented areas remain immune; this is why native breeders in Algeria select breeds of sheep which are entirely black. The pigmentation of the human skin is a function of insolation, and among his patients Molinéry (*loc. cit.*) measures the efficacy of the heliotherapy by the intensity of the superpigmentation.

In man, as well as in the plant, the pigments appear as the ultimate residuum of photochemical reactions, as a result for rather than as a cause.

III. GENERAL CONCLUSIONS

The resinous secretion is, in certain plants, *a mode of defense against auto-intoxication and senility.*[39] It contributes, secondarily, to the prevention, localization or cicatrization of parasitic infections.

A far more general fact, *pigmentation is a reaction of defense against excessive radiation.*[40] The plant lives in the shade of its chlorophyl as the negro lives in the shade of his skin.

But the pigments, even chlorophyl, are not the specific agents of biologic syntheses.

The synthesis of certain hydrocarbons has been effected without their aid, and it seems to be legitimate to conclude that it is possible to construct directly, solely by the photo-synthetic power of light, the most complex compounds, and the physical bases of life.

[23] Leaf of birch rusted by *Melampsoridium*.

[24] Spots of *Polystigma rubrum*.

[27] Pigmented plants, with active metabolism, become less heated than dry plants. Air, 0°. Capitula of thistle, red, in flower, 9 + 4. "Savage" horsethistle, dry, deflowered, 9 + 7.

[28] In warm weather, to defend themselves against elevation of temperature, living creatures waste the excess of calorific energy; animals employ a part of the energy furnished by their food to increase the activity of their sweat glands (Mallèvre); plants employ a very large part of the solar energy absorbed to increase their transpiration (Chlorovaporization, Van Tieghem). The xerophytic adaptations of the "false witches' brooms" are well known (Cf. P. Vuillemin: *Revue de Mycologie*, II. Symbiosis, *Rev. Gen. Sc.*, Aug. 15-30, 1917); the shoots of *Arbutus Uva-Ursi* and of *Vaccinium Myrtillus* colored red by the *Exobasidium*, and the leaves of wild plum trees reddened by the polystigma transpire only half as much as the normal shoots, either in the shade or in the sun.

[29] Influence of Colors on Butterflies, *Rev. Gen. des Sc.*, June 30, 1917.

[30] In the needles of the maritime pine the oleo-resins undergo inverse fluctuations to those of the starch; they diminish by day and increase by night (Bargue).

[31] According to Richards and Spoehr, the cacti contain ten times as much acid at sunrise as at sunset. The growth is slower by day than by night because the nocturnal accumulation of plant acids increases the osmotic pressure of the cells, permits the protoplasm to absorb more water and accelerates the growth, which is a function of the capacity of hydratation (MacDougal).

[32] Rusts (*Chrysomyxa* of the needles of the larch).

[33] Red colorations caused by the Ascomycetes (*Exoascus* of the leaves of the peach tree and the ♀ catkins of the adler; endotrophic mycorhizes of the leaves of the Arbutus [J. Dufrénoy: The Endotrophic Mycorhiza of Ericaceæ, *The New Phytologist*, Oct., 1917]). The rusts rarely occasion colored reactions; however the *Thecospora* redden the veins of the leaves of the myrtle.

[34] When fecundation takes place in the non-opened flower (cleistogamous flower of *Campanula pusilla*), the grains of pollen, protected by the corolla against radiation, are not pigmented.

[35] Péchoutre: Rev. de Bot., *Rev. Gen. d. Sc.*, Aug. 30, 1916.

[36] In the mosses of the upper turf beds the fertile leaves have the same form as the green assimilative leaves, and can be distinguished only by their pink color. In the water-lilies it is their depigmentation which distinguishes the petals from the sepals and the leaves.

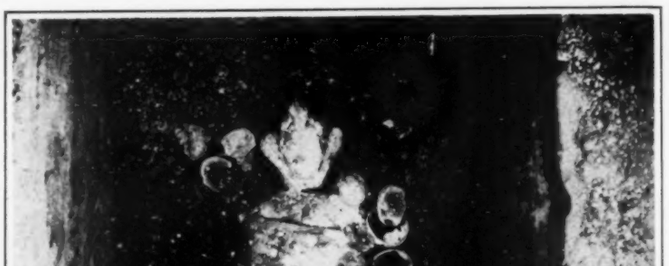
[37] The octopus reserves its sepia to be expelled only upon its enemies.

[38] Mallèvre: Zootechnology. Lecture course at the Agronomic Institute.

[39] J. Dufrénoy: Pine Needles: Their Signicance and History. *Bot. Gaz.* (Chicago) in press.

[40] Living matter must effect the integration of its own substance, and avoid its disintegration, not by causing its complex molecules to attain a state of chemical indifference and inertia—which would itself be death—but by keeping the catabolic processes inferior to the metabolic processes. Assimilation and disassimilation are regulated by luminous energy. Living matter must therefore make use of the heating and reducing energy of the solar rays; but it must protect itself against their disassimilative superactivity by means of colored screens capable of absorbing and of transforming the injurious excess of energy.

A portion of the sanctuary of Giaonas at the Villa Sciarra, Rome



Syrian bronze image found in the sanctuary of Gionas, in Rome

Syrian Remains Discovered in Rome

The Sanctuary of Gionas on the Janiculum

By Nicola Pascazio

A LACONIC notice was given to the public a short time ago to the effect that the National Museum of the Baths of Diocletian directed, with equal zeal and love by Roberto Paribeni, has opened three new halls in which have been collected the monuments relating to the Oriental religions which were imported and practiced in Rome during the Empire. The most important collection is that of the remains found in a Syrian sanctuary on the Janiculum during the last excavations made by Messrs. Gauckler, Nicole and Darier of Geneva, first; and by the *Società Immobiliare* of the Janiculum afterwards.

It is necessary to explain, although only by means of a number of inductions, the origin and importance of this sanctuary.

The attention of students was attracted for the first time to the Bosco Sacro of the nymph Furrina in 1906. While the workmen were engaged during that year in building a house for the custodian at a little distance from the Viale Glorioso, several Greek and Latin inscriptions came to light having reference to the nymph Furrina, and to some Syrian deities such as Adados, Adados Libamotes, Adados Acoreites, Jupiter Maleciambrudes, Zeus, Keraunios. Gauckler, who published an important study on these discoveries, believed that he had found the "Lucus Furrinae" on the steep slope of the Villa Sciarra, and identified the ancient goddess Furrina with the nymphs Furrine, from the inscriptions of the Imperial epoch. Again, he ascertained the existence of a spring which at the end of the second century of our era furnished the necessary lustral water for the wants of a temple of the Syrian gods, established a short time before in the "lucus," not far from the primitive nymphs.

Huelsen cast a doubt on these conclusions and called them poetical in a conference held at the Imperial Archaeological Institute in Rome and later in a memorial written by him in the *Mitteillungen*.

Gauckler instantly replied and with a wealth of argument. He proved, after having examined the strata of the Janiculum hill and attentively studied the shape of the place, that his assertions were logical.

In order to determine the existence of the temple dedicated to the Syrian divinities, he began to make excavations which at first were directed to discovering springs of water and then developed into archaeological explorations.

There resulted a discovery of three floors of edifices perfectly distinct, on account of their diverse positions and the different kinds of building.

The most ancient group was the last to be discovered; it consists of a complicated network of walls which, while Nicole was directing the works, did not seem to serve any definite purpose, and which he vaguely attributed to the second century before Christ.

To Angelo Pasqui, the zealous director of the *Ufficio Scavi Di Roma e Provincia*, they appeared to be one of the greatest works of the first century of the Empire, i. e., a piscina built to gather and to distribute the Furrine waters.

In Gauckler's opinion they are the remains of an authentic temple of the Syrian divinities, a temple anterior to that of Gaionas and which arose during that short period in which Nero favored and professed the cult of the goddess Atargatis.

This opinion seems the most dependable. That of Pasqui appears rather improbable as the buildings would have been out of proportion for collecting and distributing so poor a stream of water. And he would find a grave difficulty in logically explaining the relation existing between the vertical earthern vessels found in analogous order among the most ancient remains the "temenos," and the temple called of Gaionas, and evidently arranged for ritual reasons as they are in the "temenos" above.

The most noteworthy objects, among the more ancient remains, are the ruins of the temple of Gaionas—"cistiber Augustorum"—adorer of the Syrian divinities as many inscriptions affirm.

The sanctuary of Gaionas has the remains of some walls chipped in the upper parts and two little rooms with mosaic pavements. Its peculiar characteristic is the "temenos." It presents amphoras of absolutely new shapes, so far, for use in the ritual ceremonies.

The limits of the temple are marked out by the single line of amphoras fixed into the ground by their points, with the thick part pointing in the direction of east-west; the indications of a "decumanus" require that the amphoras should point north-south.

Besides this there was excavated, beyond the line of the amphoras running from east to west, a deep ditch whose ground was massed up towards the "temenos," consequently raising the level. The slope of the "aggere" thus created was consolidated by means of three series of thick-waisted amphoras for oil, laid in one direction. The temple was thus safeguarded from all profanation.

That the amphoras, says Aurigemma, were destined to be the *favissa* of some ritual ceremony celebrated, must be excluded, because it is evident that they were laid in the earth at one time and not on various occasions, as in that case would have occurred.

The *favissa*, true and proper, was constituted by the deep ditch from which they dug the earth for the construction of the "aggere." This *favissa*, maintained for more than a century, has given to the light an enormous quantity of scoriae, ashes, calcined bones of quadrupeds, of birds, and an infinite number of fragments of votive offerings and sacred vessels, gathered together in the course of time with offerings and the sacrifices. It is easy to recognize in the vessels and other objects the signs of the change to the Eastern religion and the cultus of those divinities.

For the various uses of the temple, the water came pure, from the source of the Furrina, to the sanctuary of Giaonas. The fount of this water has been identified by the discovery of the inscription of Giaonas and by the four canals, running in a line, which flows out in the shape of a fan. The more important of the canals followed, almost horizontally, the direction of the central axis of the sanctuary, and carried the water, necessary for the sacred ablutions, into a species of "delubrum," formed of two little rooms opening towards the south-east, furnished with all the appliances necessary for the Syrian lustration rites.

The sanctuary of which we have the most precious remains is the upper building. It is worthy of remark how the western portions of the sacred enclosure recall in a marvelous manner the structure and the forms of the Christian basilicas.

The western chapel consists, in fact, of a central crypt terminating in the apse, and of two low lateral naves, accessible from the two sides, constructed in the sides of the walls of the crypt, while on the front of this principal mass there is a transverse building divided into three unequal compartments which is absolutely analogous to the Christian "narthex."

A species of chapel of the mysteries, to which there was access by a court, is raised at the opposite extremity of the sacred cloister, the most important part of the sanctuary.

The chapel of heptagonal form, according to Pasqui, octagonal according to Nicole and Gauckler, is a chapel which was probably roofless, accessible by means of two vestibules united by an apse and presenting the aspect of a place to be kept inviolate, hedged round by silence and worshipful majesty.

Here we found the most interesting things.

In one of the vestibules of the sanctuary there was found, beside a fragment of a most elegant triangular candelabrum with a figure of nymphs and the dancing hours, a statue of Dionysos made of Parian marble, lying beside the ancient right wall of the hall, and in a most excellent state of preservation.

Dionysos has the body lightly leaning on the right leg, the right arm falls to the side, bearing in the right

hand the "Kantharos," while the left hand, at the height of the shoulder, held a thrysus which is now wanting. The statue has traces of gilding, and this is a surprising detail. The gilding is limited to the head, to the hands, to the "Kantharos," allowing us to suppose that the rest of the nude body was habitually covered with a woollen or purple vestment which would render the presence of Dionysos more fitting and compatible in a sanctuary of Syrian divinities.

In the central apse was found a statue of Pharaoh the Egyptian, in basalt, reduced to fragments but easily put together. It perhaps represents a king of the thirtieth dynasty, possibly Nestanebon, and certainly presents us with a portrait of the third century before Christ. His head is ornamented with the "Klaft" and the frontal "uraens," he has in his right hand the symbol "tan" and is in the well known attitude of motion.

The most important discovery was made in the center of the heptagonal crypt.

At the bottom of a rectangular cavity, lying horizontally, was found a bronze idol 47 centimeters in height, entirely wrapped in a woven garment, which permitted the various parts of the human body to be distinguished, and terminated above in two great knots. The aspect of the god, the delicacy of the face, the narrow waist and the development of the hips, a little accentuated, seemed to characterize this idol as a feminine deity, and as such it was proclaimed at first by Pasqui, Gauckler, Aurigemma and others.

But Roberto Paribeni, the director of the Museum of the Terma, told me that when the bronze was thoroughly cleaned it was ascertained, with absolute certainty, that it represented a masculine deity, perhaps "Hadat" or some god akin to the "Chronos mitriaco." The idol, which is enveloped in the sevenfold twinings of a serpent, like other Syrian deities, presents, between each of the spirals, traces of an egg, and indeed, seven egg-shells were found near the idol, from which we logically assume that it has to do with a mysterious rite of consecration. If we reflect, too, on the complete enclosure of the cavity which has permitted us to find the god in a perfect state of preservation after seventeen centuries, the deduction seems to be indisputable.

Has the god Zeus, found in the cave of the western temple, any significant connection with the Syrian gods? It is a divinity of dignified figure, sitting on a throne with a high back, with an ample "hination" which falls from the left shoulder and covers the legs, leaving the trunk bare. Amongst the things found, there was a human skull, one of the many enigmas without an answer which meet us in this sanctuary. And the many tombs scattered here and there breed sad thoughts and contradictory questions. Angelo Pasqui is of opinion that the inhumations took place in the most flourishing time of the sanctuary, when the temple of Giaonas existed. He believes that there is a connection between the human skull discovered in a niche of the western sanctuary and these tombs. The corpses might have belonged to great personages and to the priests of the shrine. Wissowa and Nicole opine, not without some apparent foundation of truth, that the burials took place only when the sanctuary was no longer used for purposes of worship.

On the other hand, the many brick seals found, of the times of Commodus and Septimius Severus, are a testimony in favor of Pasqui. It is to be observed that the fragments of the statue of Pharaoh in basalt have been found in a stratum nearer the surface than that of the tombs, and it must not be forgotten that, besides there having been found many seals of no rarity of the times of, and after, Diocletian, many other reasons forbid us to believe that the tombs were of the same time in which the cult of the sanctuaries flourished.

To what epoch may these constructions be referred? How long did the worship of the Syrian deities last? Were diverse cults followed in these sanctuaries? Here are three questions which are the beginning of a series, to which the most keen students of archaeology and of religious science have not been able to answer fully. While we are employed in anxiously connecting one name with another, one epoch with another, one deduction with another, an unexpected lacune occurs and stops our progress, and the investigations, silent and doubting, pause. Who can tear away the veil from the unknown? Who can force the mystery of time which confuses and obliterates all, which leads us astray, hides and dims its secret? The discussion on the age of the most recent sanctuary is still going on. Nicole assigns it to the fourth century after Christ, posterior to the time of Heliogabalus, because if it was contemporary to or had preceded it, it would have been mentioned by some writer.

But the silence of the writers does not influence for or against the doubts: the temple on the Janiculum was built by private persons, not dedicated to the gods of Emesa, to whom Heliogabalus had built two temples, so that it might easily have arisen without notice. Others think the finding of the cemetery in the precincts of the temple may lead us to believe that it had its origin during the third century after Christ. Gauckler assigns it to a more remote period, to the time of the revival of paganism attempted, and in part attained, by Julian the Apostate, but this opinion, too, has its difficulties.

The controversies and the problems raised by this temple are numberless. There is another question: whether the divinity venerated in the three successive temples was the same, and, granting that the only object of devotion was the Syrian gods, are the statues of Dionysos, of Pharoah and others to be considered as objects of a sister cult or simply offerings of the faithful?

Nicole is not absolutely convincing when he affirms that the Syrian gods opened the gates of their temples to other divinities, and that they did not exclude the cults of the classic world, that is, the Greek-Roman divinities. It is more easy to believe that the statues found belong to the "Ornamenta aedium" and not to the "simulacra deorum."

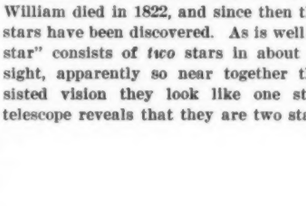
In any case Messrs. Gauckler, Nicole, Pasqui and Aurigemma merit the thanks of every category of student for having revealed to us facts unknown until now, and for having been the means of enriching Roman archaeology and the science of religions with remarkable problems and inquiries. The religions of the East come to us under another light. Interesting, also, is that mixture of Eastern and Greek Roman elements, Christian and pagan, which so marvelously result from the forms of the cults and the architectural lines.

Who can tell whether the truth has been fully revealed or whether there are not a thousand points missing

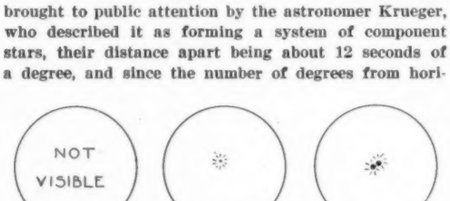
If the truth has not been revealed to us today nor yesterday, it will be tomorrow. We must arm ourselves with faith and go on searching.

An Interesting Double Star

As far back as the times of Sir William Herschel astronomers were interested in "double stars." Sir William died in 1822, and since then thousands of these stars have been discovered. As is well known, a "double star" consists of two stars in about the same line of sight, apparently so near together that to our unassisted vision they look like one star. However, a telescope reveals that they are two stars.



All double stars are more or less interesting, but one of the most interesting modern double stars was first brought to public attention by the astronomer Krueger, who described it as forming a system of component stars, their distance apart being about 12 seconds of a degree, and since the number of degrees from horizon to horizon are 180 we can see that two stars firmamentally separated only 12/3600th of 1 degree would certainly appear to our unassisted sight as just a single star.



Double stars are of two kinds: those that are not physically associated and those that form a system, one of them perhaps revolving around the other. This interesting modern double star, known as "Krueger 60," has been found to belong to the latter class.

It is interesting for at least two reasons: first, its movement across the darkened sky is comparatively rapid, and, then, it is situated *relatively* near our earth. In other words, this double star changes its position in the firmament about one second of a degree each year—not much apparently but it must be moving pretty fast through space to make such a firmamental change; and although its brightness has been estimated as being about of the ninth magnitude it is, comparatively speaking, one of our nearest neighbors lying outside of our Solar System. That is, its distance from our earth approximates 13 light-years or about 80,000,000,000,000 miles. This is certainly a vast remoteness but then the nearest known sun of night is sparkling about 26,000,000,000,000 miles away.

The two stars constituting this double-star system are of different brightness, respectively of the ninth and the twelfth magnitude, and since these stars are practically at the same distance from us and are about of the same mass the star known as A must be intrinsically brighter than the star known as B. This is another interesting fact about this double star; and it is also interesting to consider that both these associated suns have in all probability solar systems (planets) of their own, with the possibility that at least one of the satellites probably revolving around A and B of this very interesting sidereal system may possess a civilization equal or superior to that which exists upon our own little planet.

CHARLES NEVERS HOLMES.

To Keep the Airmen Warm

IT is stated that a means has been discovered for keeping airmen warm at great altitudes by providing them with electrically-heated clothing. Should this become an easily applied system we may do away with heating in our buildings, as our collars, handkerchiefs, underclothing, and other garments may supply us with all we need, says a note in the *Builder*. We may in the future be as comfortable with the temperature below zero as we are now in a well-heated building, and the bath of the future may be warmed to any desired heat if we place it in the neighborhood of a well-filled wardrobe. If we want to eat an ice it may be necessary partially to undress, since the proximity of a well-dressed man or woman may reduce the ice to liquid before we can eat it. Assuming the control of temperature to be within our grasp it is possible we shall have automatic contrivances by which our clothing will give out a greater or less degree of heat. A suit will be guaranteed to preserve a temperature of 60 degrees for the wearer, the outer air being anywhere between 16 degrees and 40 degrees. A suit to give a greater temperature would presumably cost more, irrespective of material. When the discovery has been fully developed the heating engineer will find his occupation gone.—*The Engineer.*

Detection of Foreign Oils in Castor Oil Used for Lubricating Aeroplane Motors

THE acetyl value is capable of indicating the presence of one to two per cent of foreign oils in castor oil, but the other constants are of little value for the purpose. In the special case of castor oil adulterated with arachis oil the solidification point and the solubility in alcohol are the most sensitive tests (limit, 5 per cent). For smaller amounts of arachis oil the turbidity temperature of the alcoholic solution may be determined. A solution of one volume of pure castor oil in 95 per cent alcohol remains clear when chilled below —20 degrees C.; but in the presence of arachis oil the solution becomes turbid at temperatures ranging from +5 degrees or +6 degrees C. for 5 per cent to —2 degrees or —3 degrees C. for 2 per cent of arachis oil. An alcoholic solution of castor oil containing one per cent of arachis oil becomes opalescent at —4 degrees to —5 degrees C. and turbid at —9 degrees C. Foreign oils may be separated from castor oil by shaking 20 c.c. of the sample with 80 c.c. of petroleum spirit of b.pt. 35 degrees to 70 degrees C. in a stoppered graduated cylinder. After settling, the volume of the lower layer containing the castor oil will show an increase of about 11 to 12 c.c. if the oil is pure, or more if foreign oils are present. On evaporating 50 c.c. of the petroleum spirit layer a residue is left, which in the case of 12 samples of pure castor oil ranged from 8.35 to 8.70 per cent of the original oil. Mixtures containing from 30 to one per cent of arachis oil gave residues ranging from 38.61 to 10.04 per cent and by deducting from these the average value for pure castor oil (8.52 per cent), the results agreed closely with theory. The method also effects a concentration of the arachis oil, which facilitates the detection of arachidic acid by Bellier's method. For example, the petroleum spirit extract from castor oil containing 5 per cent of arachis oil will contain 36.7 per cent of that oil—Note in *Jour. Soc. Chem. Ind.* on an article by C. FRABOT in *Ann. Chim. Analyt.*

The Mosquito Question*

Migration as a Factor In Control

By Thomas J. Headlee, Ph.D. Entomologist of the New Jersey Agricultural Experiment Stations and State Entomologist

THE practical work of mosquito control has gone far enough to demonstrate that migrating adults of various species of mosquitoes frequently so complicate the problem of freeing a limited locality as to render successful work impossible. This fact when taken with the further fact that interest in the practical problem of control is growing would seem to justify an examination of the data bearing upon mosquito migration in the hope of finding out how to minimize its effects.

EVIDENCE OF MOSQUITO FLIGHT

Howard, Dyar and Knob[1] have brought together a mass of data bearing on the question of mosquito migration. As might be expected there is much evidence of flight without any indication of the species concerned but there is also much where the species has been determined. The accompanying table will serve to give the facts.

It thus appears that the far migrating species are those which breed on the salt marshes, that twenty-five or thirty mile movements are common, and that extremes of sixty miles may be reached.

The writer has traced the salt marsh species *A. cantator* and *A. sollicitans* during each of the last five summer seasons and has found them penetrating the back country for long distances. Twenty-five mile migrations are common and thirty-five to forty miles take place when the brood emerging is very large. *A. cantator* has not been observed to cover the distances reached by *A. sollicitans*, but the difference may be due to the cooler weather and the smaller broods of the former.

Russell (see table) has shown a flight of two miles for *Anopheles annulipalpis*. LePrince and Orenstein[2] have cited incontrovertible evidence to show a flight of 6,250 feet by *Anopheles tarsimaculata* and *Anopheles albimanus* (the latter is a very important carrier of malaria).

Headlee[3] has collected evidence to show the movement of the house mosquito (*Culex pipiens*) from an area of very intense breeding to a point fully 2.5 miles away.

Smith[4] records that the fresh-water swamp mosquito (*Aedes sylvestris*) may migrate as far as five miles.

In the month of May, 1917, heavy rainfall flooded a large part of the upper Passaic River valley, which contains many thousands of acres of fresh-water swamp land. While the waters were still spread over a large portion of this swampland Mr. R. W. Glies and Mr. W. V. Becker traversed a large portion of it in a canoe and found very small larvae of the fresh-water swamp mosquito (*Aedes sylvestris*) everywhere in the quiet water. The water fell with sufficient rapidity to destroy the breeding on the better drained portions of the valley, but enough escaped from the undrained sections to make trouble in June.

To the north and west of this valley lay successive ranges of low mountains beginning at an elevation of about 400 feet and increasing rapidly in height, with gaps leading only to higher elevations and sparse population. To the south and east lay two ridges of low mountains with an extreme height of a little over 400 feet and with deep gaps leading out upon level or rolling plains of low elevation and dense population.

On June 15th a series of daylight collections made from Newark to and across the upper Passaic valley showed the fresh-water swamp mosquito in constantly increasing numbers from East Orange to Hatfield swamp, the nearest piece of swampland in this valley, and in rapidly decreasing numbers until the collecting ceased on the north shore of the valley. From East Orange to Hatfield swamp as the crow flies is about 7 miles in the course of which the two before mentioned ridges rear their crests. By the roadway followed in making the collections the distance was about 10 miles.

Beginning on June 20th, series of collections were made on all sides of the upper Passaic River valley. These collections show a rapidly disappearing density to the north and west, a more slowly diminishing density to the south and east and the greatest density in the areas facing the gaps which lead from this valley to the south and east.

Inasmuch as the fresh-water swamp mosquito had by this date had time to effects its distribution: (1) the low and rapidly decreasing density to the north and west may be taken to indicate that movement in that direction was slight; (2) that the more slowly decreasing density to the south and east may be taken to indicate that the movement in the direction was more pronounced; (3) that the greater and more slowly decreasing density in the areas which face the gaps leading from this valley to the south and east may be taken to indicate that the principal movement occurred through these gaps.

CAUSE OF MOSQUITO FLIGHT

The cause of mosquito migrations is obscure but it is safe to assume they are in some way related to one or both of the great necessities of living matter—persistance of the individual and the reproduction of its kind.

The mosquito emerges, its body wall hardens, its parts become adjusted, and it flies away in search of food and opportunities for reproduction. Usually these desired conditions are found nearby. The female alternates between places where food may be had and places where eggs may be laid.

This is the type of movement exhibited by the mosquitoes that breed about human habitation (the house mosquito) and the underlying causes are very evident.

When the same species breeds very intensely upon a very large area, it tends to move from place of breeding and may cover in some cases a distance of 2.5 miles. The movement must be made in response to a desire for food because opportunities for reproduction are unlimited. No doubt the specimens that find food near the place of birth return to the source for reproduction, but those which migrate further for food find breeding spots nearer the source of food supply. There is no evidence to indicate that this movement of the house mosquito takes place rapidly, but the facts in hand point rather to a slow dissemination.

When dealing with a species that lives in the wilds, such as the more important *Anopheles* (malaria carrying kinds) the movement to secure food may take on a very different character. LePrince and Orenstein have shown that *Anopheles albimanus* and others made their way for a distance of ½ a mile to a village, apparently in search of food and that they or others of the same species make a return flight before morning.

The fresh water swamp mosquito when bred in small numbers seems to have the same movement as the house mosquito, but when produced in enormous numbers, over a large area, may cover long distances in its search for food. Under such circumstances it is likely to find breeding places near its food supply and probably rarely returns to the place where it was bred.

A small brood of salt marsh mosquitoes (*A. cantator* and *A. sollicitans*) will travel only a short distance for food and return to the marsh for laying eggs, but a very large one will throw off an immense number of migrants which will fly for long distances over territory in which no suitable breeding ground exists. Of course, such flights multiply the insects' chances for obtaining food and also in some cases new breeding grounds. The fact that most of the migrants exhibit undeveloped ovaries does not necessarily mean that breeding cannot take place when the new breeding grounds are reached.

It really seems as if intense breeding over large areas is followed by wide distribution of the adults of the house mosquito (*Culex pipiens*), the fresh-water swamp mosquito (*Aedes sylvestris*), and the salt marsh mosquito (*Aedes cantator*), and *Aedes sollicitans*. It is possible that under similar conditions *Anopheles* (some of which carry malaria) would be found to act similarly.

EXTERNAL FACTORS WHICH INFLUENCE FLIGHT

Without doubt low temperature reduces, may suspend, or even destroy the activity of the adult mosquito. Excessively high temperatures always retard mosquito activity. A warm temperature, 80° F., is extremely favorable.

Light is avoided by most species and some have such an abhorence of it that they will not become active while it is strong.

Atmospheric moisture has a very powerful effect upon the adult. High percentages are favorable and low percentages deadly. Rain itself is decidedly injurious and prevents adult mosquito activity.

Air movements greatly influence mosquito activity. A stiff breeze is usually quite sufficient to stop their movements and to compel them to cling to shelter. Winds of low velocity (10 miles an hour or less), of high temperature (about 80° F.) and high humidity appear to be the ones that favor long flights.

The observations of practically all investigators indicate that the salt marsh species in long migrations travel with the wind.

On the other hand, LePrince and Orenstein found the *Anopheles* flying either against the wind or at right angles to it. Russell, however, records *Anopheles annulipalpis* as coming aboard ship on a breeze from the land.

The zone of house mosquitoes described by Headlee did not extend in the direction of the favorable winds. The mosquitoes seem to have moved in the direction of dense population.

The migrations of the fresh water swamp mosquito extended southward and eastward much further than northward or westward, while the more favorable winds would seem to urge them in the opposite directions. It is quite possible that the ranges of low mountains with which the home of this brood of the swamp mosquito was surrounded may have had something to do with the direction of migrations, for the openings lay to the south and east. To go to the north and west was to encounter a succession of ridges, while to migrate southward meant much easier going.

Date	Investigator	Place	Species	Number of Miles
1879	Mitchell	Matagorda Bay	Unknown, Probably salt marsh	50-60
1884	Hetherington	Ship "Gedney"	Unknown	27
1886	Mitchell	Matagorda Bay	Unknown, Probably salt marsh	50-60
1903	Russell	Ship "Newark"	An. annulipalpis	2
1904	Smith	New Jersey Seacoast and Bay-coast	A. sollicitans A. cantator	30-40
1904	Carter	Gulf of Mexico off Louisiana coast	Salt marsh	15-18
1908-10	Mayer	Dry Tortugas	A. niger Salt Marsh	40
1909	Young	Ship "Concho"	Unknown	60

CONCLUSIONS

The ordinary short flights of all species between food and breeding places, that serves to keep the species going in localities where they are already established are in all probability initiated by food and breeding place odors. That these stimuli may excite movements of considerable distances is indicated by the studies of LePrince and Orenstein in Panama.

When, however, we consider the long-distance flights of any species, the breeding conditions of which have been carefully studied, we find that they arise only where the species concerned has bred very intensely over a large area.

Naturally, under these conditions the food supply would be less than normal and the flight might be due to that fact.

Air currents, so long as they are not too high to prohibit movement, would seem not to effect in any important way the short ordinary flights, but seem to be a determining factor in long-distance movements. Ordinarily the flight in such cases goes with the slow moving, warm, damp wind, but modifications in direc-

*A paper read before the American Association of Economic Entomologists.

[1] "The Mosquitos of North and Central America and the West Indies," vol. I., pp. 339-345, Carnegie Institution Publication No. 159.

[2] LePrince, J. A., and Orenstein, A. J., "Mosquito Control in Panama," pp. 94-114.

[3] Headlee, Thomas J., Bulletin No. 306, N. J. Agric. Expt. Station, pp. 6-7.

[4] Smith, J. B., Report of the N. J. Agric. Expt. Sta., on the Mosquitoes occurring within the State, 1904.

tion of flight may be due to mountain ridges and possible other factors not at present recognized.

BEARING OF THESE FACTS ON THE PROBLEM OF CONTROL

The facts just set forth show clearly that flights of salt march, fresh-water swamp, malarial and house mosquitoes may seriously interfere with the project of keeping a specified locality free of mosquitoes, and indicate that plans and estimates for practical control work must be based on something more than a study of the mosquito breeding places within the specified area—must include an analysis of the mosquitoes on the wing throughout the said locality for at least one summer season. They show further that the practical work of control must be accompanied by a thorough knowledge of the adult mosquitoes that are abroad in order that the trouble due to local breeding may be distinguished from that arising from invasions and in order further that the sources of the invading pests may be found and eliminated.

The Cruisers of the Rails

SUCH admirable service has been rendered since the beginning of the war by French navy. gunners detailed to land service that the French Minister of Marine, M. Georges Leygues, has just presented them in a formal ceremony with an individual flag, the gift of the city of Toulon. The cut herewith shown, taken from a number of *l'Illustration* (Paris), shows an armored train equipped with the big cannon heretofore employed for ocean cruisers.

It was at the very beginning of the war, August 9, 1914, when the Minister of Marine tendered to the Minister of War a certain number of cannon of 14 to 16 cm. caliber with the personnel required to equip them. The acceptance of this offer was hastened by the menace to Paris occasioned by the German offensive. Detachments of gunners from Brest and Lorient were assembled at Sevran-Livry, and this first formation furnished the armament of the turrets for 155 forts and the personnel of the "auto-projectors."

After the victory of the Marne the marine gunners were sent to Verdun and to Toul and later to Belfort with 14 and 16 cm. guns. In August, 1915, naval guns of 10, 14 and 16 cm. caliber were put at the disposal of the "armies of the Center" and took part in the September and October offensives in Champagne, either as *pièces de position* or as mobile pieces of ordnance on gunboats and pinnaces for battering railways and important objectives outside the range of heavy artillery. After the destruction, by the German offensive of February, 1916, of the positions they occupied at Verdun the marines continued, in spite of the heavy losses they had suffered in material equipment, to assist in the defense of the place by organizing the works of the second line with marvelous dispatch and dauntless courage.

Batteries of marine gunners and of river boat gunners took part, under the command of Captain Jehenne, in the offensives of the Somme in July, 1916, and of Verdun in the following December; in 1917 they operated vigorously on the Aisne, in Champagne, in Lorraine, in Flanders and at Malmaison.

Meanwhile naval gunners were also used to man the big 19 centimeter guns used to equip armored trains as shown in the accompanying photograph. On board these "cruisers of the rails" they accomplished bombarding raids with a rapidity and precision of execution which earned them many times the warm praise of the General Staff.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Best Deglet Nur Grown in America

The article in your issue of March 2 on "Deglet-Knour, Fruit of the Desert," quoted from the *London Daily Telegraph*, suggests that you or your readers might like to know more of this date in its "American aspects," so to speak.

It is known in this country as Deglet Nur (or Noor), which, translated, means "Date of the Light," and is one of the finest varieties of dates to be found in commerce. It is a late-ripening date, consequently it is only grown commercially where the summers are long and hot. Its requirements in the way of heat and dryness of air are fulfilled in very few places in the world. In experiments dating from 1890, the Bureau of Plant Industry of the U. S. Department of Agriculture has found that the Coachella Valley, an arm of the Colorado desert lying immediately north of the Salton Sea in California, is perfectly adapted, climatically, to the culture of this prince of trees, being the hottest, dryest portion of the United States.

Here has been laid the foundation of an industry that will soon, in the opinion of those who should know, eclipse the far-famed citrus industry of California in money value of its product. Experimental plantings by private ranchers in this valley are now in bearing and have proven the correctness of the Government estimate as to the adaptability of the famous Deglet Nur. The trees, imported from Tunis, bear regularly and heavily of fruit that surpasses the product of the Old World. When packed with American taste and cleanliness, as the growers in Coachella Valley are now doing, the dates do not compete with the same variety from North Africa, outclassing the latter to such an extent that the demand far outruns the supply at one dollar per pound. If it were not for this fact, namely, that the last fall's crop was merely a drop in the hungry market and consequently none are now available, I should send some along with this letter for your consideration, as I know they would be far more effective than any letter I could write.

In parentheses I might say about the popularity of the American-grown Deglet Nur, that notwithstanding there has been no advertising of its merits other than the recommendations of those who have eaten it, the entire crop is generally sold four months before the harvest (which occurs October to December) to private buyers who put in their reservations as early as possible in order not to be disappointed.

I hope this does not sound like an advertising letter, as I had no intention of making it so. In reading of a subject that interests me so, I could not help wondering if others might not like some light on a very little-known branch of American horticulture; and it also occurred to me that I might as well give such further information as you would want if you were interested. The Coachella Valley date needs no advertising at present, and, judging by the way the demand is increasing, will need none for years to come.

My own crop is already contracted for among my personal friends, so I have none for sale.

W. F. A. MCINTYRE.

P. S.—In regard to date stones, which your article says are used as camel food in North Africa, it has been found that, when ground, they form a food nearly as nourishing as the flesh of the date, showing a content of digestible carbohydrates of nearly 50% (I haven't the exact figures). They are thus good food for humans as well as camels.

Oil Recovery Methods

THAT much of the oil in a field is never recovered is well known, but how large a proportion is left underground and the possibility of increasing the recovery can not be fully realized until one clearly understands that the exhaustion of an oil well is due more to the exhaustion of the natural gas, which is the principal agent in driving the oil into the well, than to the exhaustion of the oil itself.

Facts presented in this bulletin go to show that the capacities of the oil sands in the various fields of the United States are five to ten times greater than the quantities of oil commonly extracted from them. If it could be fully established, as seems most probable, that the pores of the oil-bearing sands were completely filled with oil at the time the fields were first developed, then eighty to ninety per cent of the oil is left underground when the wells are abandoned. Although the evidence at hand does not permit positive statements that this proportion is being left underground, there is abundant evidence that much oil capable of being recovered remains in the sands. Complete extraction is not to be hoped for, yet there is no reason to conclude that the maximum possible recovery has been reached when the natural forces have been exhausted, and, furthermore, it has been demonstrated that it is practicable to get more oil from the sands by the processes described in this report.

It is too soon to know just how much to expect from these methods of increasing recovery, but the results have been so encouraging that they give possibilities of new values to the properties of every producer and to the country as a whole as a new source of supply to ward off the threatened shortage. It would thus seem the part of wisdom for the individual producer and for the general public to see that the oil fields are left in condition to use these or any new or improved processes that may be discovered in the future. It should be insisted, as far as practicable, that oil wells not now profitable be abandoned in such manner that they may be reclaimed at some later date, when, as seems probable, new discoveries and improved economic conditions will make their operation profitable once more.

The problem of increasing recovery divides itself naturally into two phases—a better utilization of the natural forces in the oil-bearing formations and the employment of artificial pressures. Under present conditions probably the only generally feasible methods for recovering more oil from the formations after the natural forces have been exhausted involve the forcing of gases or liquids through the oil-bearing formation. Of the gases that might be used, only air and natural gas are practically available, and of the liquids only water.

The oldest and most extensively used of the methods previously mentioned is gas or vacuum pumping. By this method the pressures at the wells are reduced, permitting further expansion of the gas and the expulsion of more oil from the oil-bearing formations, but experience has shown that it is not adapted to all localities, and where used has only slightly increased the total recoveries from the fields. Productions of wells may be increased several times, but the benefits are temporary and the additional expenses of operation usually consume the additional gross value of the production. Were it not for the gasoline extracted from the increased volume and enriched gas, gas pumping would seldom be profitable.

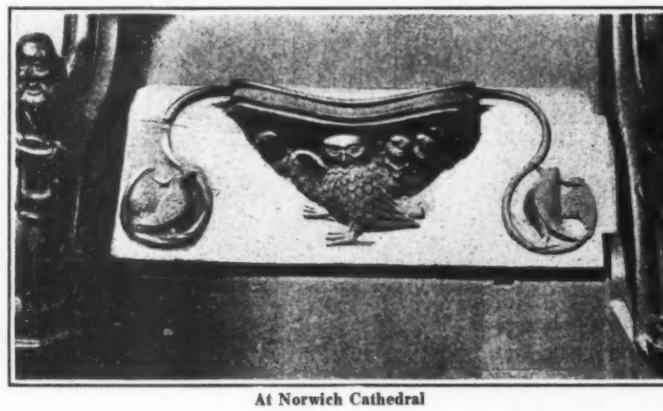
Displacing the oil from the pores of the oil-bearing formations by water, commonly known as flooding, has seldom been successful, the conspicuous exception being in the Bradford field, Pennsylvania, where letting fresh water into the oil sand undoubtedly has resulted in increased recovery. As flooding practically ends all further possibilities of increasing recovery by other methods, its employment until other methods have been tried seems a shortsighted policy, even where positive results have been obtained and conditions are believed to be exceptionally favorable, as at Bradford. Elsewhere flooding has ordinarily done more harm than good, and in the occasional instances where a property has been benefited it is usually at the expense of other properties near by. Flooding has been held in general disfavor, though a few advocates have claimed that the faults lie mostly in the ways in which it is applied. In the writer's opinion natural conditions preclude its extensive success, and it is doubtful whether as much oil is being obtained, even under the exceptionally favorable conditions at Bradford, as would be possible by other means. Certainly its use in untried fields is hazardous.

In the Smith-Dunn process, also known as the Marietta process, through its first extensive use at Marietta, Ohio, compressed air is forced into the oil-bearing formation through a few of the wells on a property, thus forcing the oil underground toward the other wells, from which it is pumped in the usual way. The process has been successfully used for nearly six years and has been applied to about one hundred properties, including about four-thousand wells mostly located in the Appalachian fields. It has been successful in at least eighty per cent of the cases where used, and the records of 32 properties show an average increase of three and one-half times the production at the time the process was started. The process offers such possibilities of extended application and of further improvements that it is thought to be the most promising of the methods so far advanced for increasing recovery. Natural gas can be used similarly, but because of the scarcity and value of natural gas where such methods will be resorted to, its use will less often be practical.

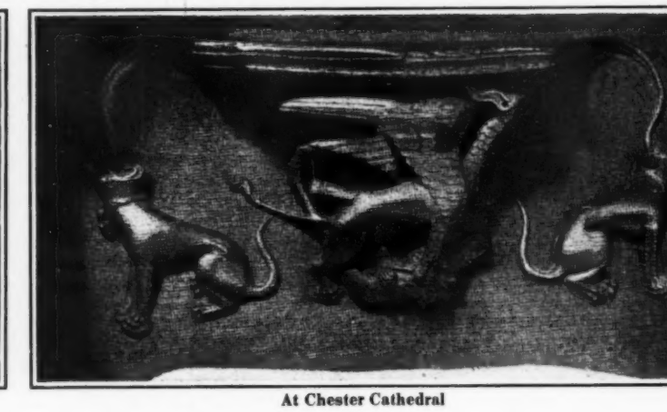
As the exhaustion of a well depends principally upon the exhaustion of the gas associated with the oil, more efficient utilization of the gas in forcing the oil from the productive formation would result in increased extraction. Only limited efforts have been made to apply this principle practically, but it deserves extended investigation. The employment of the Marietta process, wherein the movements of the oil and air can be traced, has disclosed much information capable of being applied profitably to the production of oil by natural forces.—From *Bulletin 148, Petroleum Technology 37* issued by Bureau of Mines.

Height at Which Sounds Can Be Heard

IN one of his journals, Camille Flammarion gives the heights at which sounds from the earth are heard from balloons. The shout of a man was heard distinctly at the height of 1,600 feet, the sharp note of a mole-cricket at 2,500 feet, and the croaking of frogs in a morass at 3,000 feet. At 3,255 feet a man's voice and the rolling of a cart were distinguished; at 4,550 feet the roll of a drum and the music of an orchestra; at 5,000 feet the crowing of a cock, the sound of a church bell, and sometimes the shouting of men and women. Nine hundred feet higher still he heard the report of a musket and the barking of a dog. The noise of a railway train penetrated to a height of 8,200 feet, and the whistle of a locomotive engine to nearly 10,000 feet.



At Norwich Cathedral



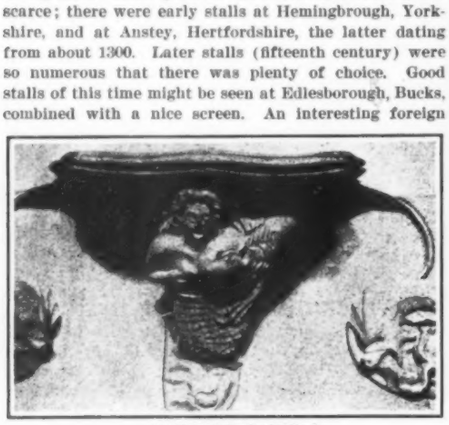
At Chester Cathedral

Mediaeval Choir Stalls—I*

Design and Decoration of Misericord Seats

At a meeting of the Royal Archæological Institute, held in the apartments of the Society of Antiquaries, Mr. G. C. Druce, F. S. A., delivered a remarkably interesting address entitled "Notes on the Design and Decoration of Misericord Seats," which was finely illustrated by lantern slides. Sir Henry Howorth (president of the institute) was in the chair.

Mr. Druce said that what he had to offer was not a research paper but rather a demonstration, the object of which was to show first the chronological development of misericord seats, and, secondly, the way in which the decorative detail was arranged on them. He took it that everyone there was acquainted with the general character of choir-stalls, and the position that misericord seats occupied in them. The greater number of stalls were ranged along the north and south walls, a few (generally three or four) being returned at the west end—i. e., backing against the screen, and so facing east. Stalls prior to the fourteenth century are scarce; there were early stalls at Hemingbrough, Yorkshire, and at Anstey, Hertfordshire, the latter dating from about 1300. Later stalls (fifteenth century) were so numerous that there was plenty of choice. Good stalls of this time might be seen at Edlesborough, Bucks, combined with a nice screen. An interesting foreign



At Norwich Cathedral

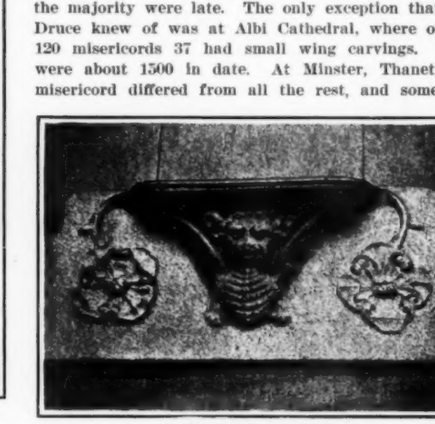
example of early sixteenth century date was shown from the church of St. Marcel, near Argenton-sur-Creuze.

Misericord seats were hinged and had a ledge projecting from the underside. When the seat was raised the ledge afforded a convenient support to the body of a standing man. Some such support was needed by aged and infirm monks during the long offices, hence their name from the Latin "misericordia." The sides of the divisions between the stalls were cut out in the form of a quadrant, within which the ends of the seat revolved, the base of the recess providing a firm bearing for the board, to take the sitter's weight. The under side of the seat was usually carved with either foliage or figure subjects, and therefore formed an important decorative feature. From that fact they might conclude that the seats were intended to be raised when not in use. Not much effort was needed to sit down in a seat, but it was a different matter when one wanted to get up, especially if old or infirm, so arm or hand rests were provided. Support in this way was first gained by the curve of the projecting division, but afterwards "elbows" were added, and these were also the subject of decoration which harmonized with that of the misericords. This decoration, composed of either foliage or figure subjects, was not allowed to interfere with the utilitarian purpose of the arm-rest, as it was practically always round and smooth on the top. The manipulation of figure subjects to meet this requirement was often very clever, the curve of the head or back of an animal or of a leaf being made to serve. In the same way, when standing, support

Stalls at Anstey, Herts

for the arms was gained by the flat top of the division between the stalls, but, exceptionally, at Balsham (Cambs.), where the construction differed, an upper tier of richly carved arm-rests was provided.

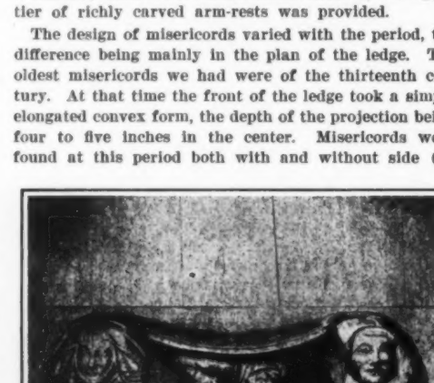
The design of misericords varied with the period, the difference being mainly in the plan of the ledge. The oldest misericords we had were of the thirteenth century. At that time the front of the ledge took a simple elongated convex form, the depth of the projection being four to five inches in the center. Misericords were found at this period both with and without side (or wing) ornamentation. Mr. Druce showed an example at Anstey without wing subjects, and said the misericords there were interesting as the ledges were not under-cut but left full, and the subjects on them appeared as if applied to the surface. In the case of misericords with wing ornamentation the rounded edge or moulding of the ledge was extended, first sideways, then downwards, forming a connecting stalk for the wing subject. This stem or stalk might be so little developed in early misericords as to be scarcely visible, for example, on the single surviving misericord at Hemingborough. At Exeter Cathedral the wing foliage on the thirteenth-century misericords had stems varying in length, but in no case as long as in later work. The occurrence in this country of a few misericords of early date without wing subjects raised an interesting question, for they were practically universal on the Continent. Maeterlinck illustrates some of the thirteenth century at Hastiere, and of the fourteenth century at Liège, but the majority were late. The only exception that Mr. Druce knew of was at Albi Cathedral, where out of 120 misericords 37 had small wing carvings. They were about 1500 in date. At Minster, Thanet, one misericord differed from all the rest, and somewhat



At Winchester Cathedral

resembled those at Albi in design. Illustrations of foreign examples were shown. Maeterlinck illustrates stalls at Ratzburg of the twelfth century, showing misericords without wings, and Mr. Druce suggested that if we could go back to the beginning of our English misericords we might find they were all of the same simple character as those on the Continent. We had, however, nothing to go by earlier than the thirteenth century, and could not positively say that there were any in existence in the twelfth century, but if there were one could not help wondering what they were like, and whether our misericords generally were introduced from abroad. The prevalence of wing carvings here was at any rate an argument in favor of our misericords having been carved by native craftsmen.

With the change from the thirteenth to the fourteenth century the first modification appeared in the plan of the ledge. The front became flatter and the sides were pushed in, with the effect of forming a pair of shallow foliations. The ledge was also hollowed out on the top. The change might well be seen at Winchester Cathedral, and the new design was generally current until past the middle of the fourteenth century. Winchester misericords were well carved, and were remarkable for the small size of the center-



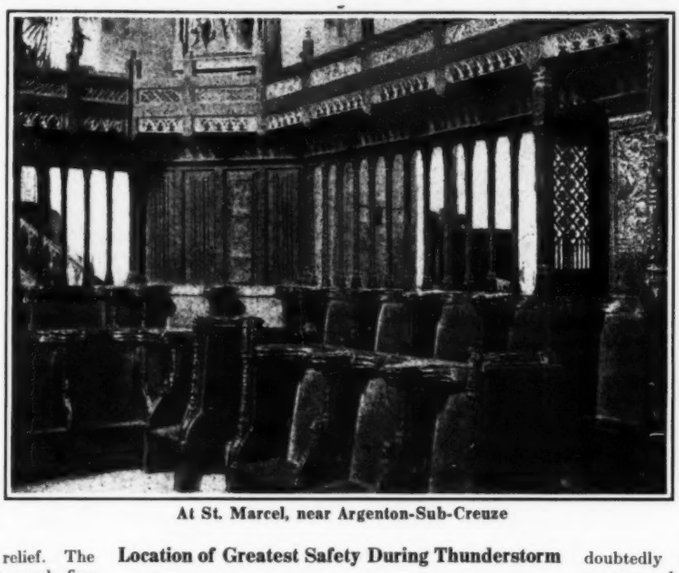
At Hemingborough

*From *The Architect*, London.

pieces. At Wells where they dated from about 1330, the ledge was of much the same form. The centerpieces were larger than at Winchester, but the wing subjects at both places were close to the ledge. The work at Wells was beautifully executed and naturalistic in style, but some of the figures lacked strength. There were two sets of misericords of the early part of the fourteenth century at Chichester—at St. Mary's Hospital and in the cathedral. At St. Mary's the ledges were of the usual fourteenth century type, with the sides pushed in, but they had to note the development of the stalk and the small size of the wing subjects, as in some of the thirteenth century examples. The workmanship was also very good. At the cathedral the design was much the same, but the wing subjects were closer up. There were certain correspondences in the figures at both places, but they could not have been by the same hand. At Ely Cathedral, nearer the middle of the century, the chief thing to note was the way in which the ledge was undercut, creating a very deep shadow, and consequently the figures stood out in high relief. The misericords at Ely were well carved, with much fine detail. Passing to the earliest of the misericords at Norwich Cathedral, the date of which Mr. Druce said he should put at 1365-70, he remarked that there was a further modification in the ledge, involving an increase in the hollow curve of the front, but the latter was still broad. These misericords formed a stepping-stone to the next that he showed and which introduced a more decided change, corresponding with a transition period in architecture. They were at Etchingham Church, the date of which was approximately known, It was built by Sir William de Etchingham, who died in 1388, and the chancel was probably finished about 1365. The shape of the ledge here closely agreed with Norwich, but, in addition, there was a small point in the center of the front. It was therefore divided into two parts, forming two foliations in addition to the two at the sides, the corners remaining unaltered. Combined with this, the mullion in the window tracery of the misericord shown on the screen was continued straight up to the head, so that it was verging towards the perpendicular. This breaking up of the ledge into a number of foliations led naturally to the introduction of coving, for up to this time the under surface of the ledge had been simply sloped off. Showing an illustration of one of the second group at Norwich Cathedral, depicting Samson and the lion, Mr. Druce observed that it was not much later than the others at Norwich, but there was a distinct difference in the ledge, for it had a decided point in the center of the still broad front. What was more, the round corners had given way to small foliations, so that the ledge was now practically sexfoil. He should put this group at about 1380 in date, and they might well have been by the same hand as the first. At Lavant, Sussex, there was the same type, with six foliations, but with the front still broad. The coving was distinct, and the centerpiece was placed at the foot; this had the effect of keeping the carved subject on the small side. As they proceeded the plan of the ledge became more or less stereotyped, and there were many examples. The breadth of the corner foliations tended to increase at the expense of the front, which became narrower. Lincoln afforded an example, and, judging by the provision made by John de Welborne (Treasurer, 1356-80), the misericords there should date about 1380. Chester followed Lincoln not long after in date, and there was correspondence both in subject and style. An illustration from Chester, showing more equal foliations, depicted the legend of the Unicorn. On later misericords equality of foliations sometimes became quite pronounced, as at Godmanchester. The coving there was very marked, and the carved subjects were low down.

Another good example of equal foliations and distinct coving was to be seen at Stratford-on-Avon, the date being late fifteenth century. At Balsham, also the foliations tended to be equal, and it had to be noted that the moulded edge frequently became deeper and richer in the later misericords. At Throwley, Kent, there was good moulding quite Perpendicular in style, and at Manchester, where the misericords were late (1508), the moulding was deep. At Beverley Minster again, the ledges were enriched with a scalloped ornament, while at Bristol Cathedral, where the misericords were of the sixteenth century, the mouldings were deepest of all.

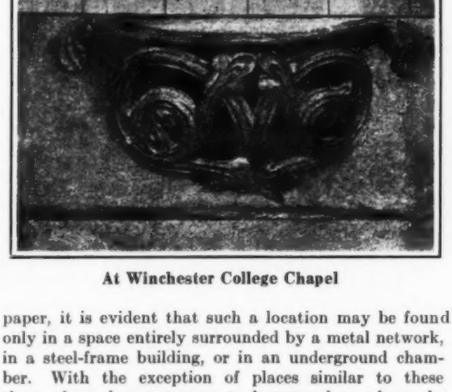
(TO BE CONTINUED)



At St. Marcel, near Argenton-Sub-Creuze

Location of Greatest Safety During Thunderstorm

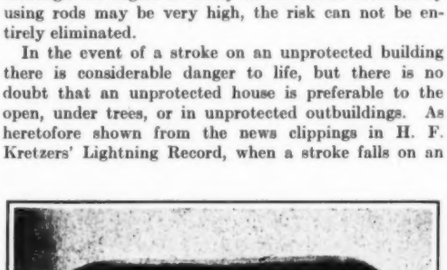
THE question is often asked as to the location of greatest safety during a thunderstorm. In this respect it may be said that there is no place or object in the path of a thunderstorm that is not liable to a stroke of lightning. Places or objects may be more or less liable to a stroke of lightning according to their relative exposure, etc., but no place in the path of a thunderstorm is to be considered as one upon which a stroke of lightning is not likely to fall. The location of complete safety during a thunderstorm is, therefore, one in which, even though a stroke of lightning does fall upon it, no harm will come to the occupant. From what has been said in the foregoing portions of this



At Winchester College Chapel

paper, it is evident that such a location may be found only in a space entirely surrounded by a metal network, in a steel-frame building, or in an underground chamber. With the exception of places similar to these three, there does not seem to be any place where absolute safety may be obtained. The next degree of safety is undoubtedly to be found in houses or other buildings which are protected by lightning rods, but although the degree of safety which can be attained by using rods may be very high, the risk can not be entirely eliminated.

In the event of a stroke on an unprotected building there is considerable danger to life, but there is no doubt that an unprotected house is preferable to the open, under trees, or in unprotected outbuildings. As heretofore shown from the news clippings in H. F. Kretzers' Lightning Record, when a stroke falls on an unprotected house sheltering a family of the average number of persons, the minimum chances of escape are 45 in 100. In all probability, however, the chances of escape are much greater than this. In 254 instances of casualties in unprotected houses which are given in this record, there were 117 cases of death and 137 cases of injury. From the same source it is found that in 153 cases of persons struck in open fields, 116 were killed and 37 were injured. In 9 cases of persons struck near wire fences, 8 were killed and 1 injured. It seems, therefore, that it is far better to take shelter in a house which is not protected against lightning than to take chances in the open, where everything is damp and hence the liability to shock or injury far greater than in a dry place.



At Anstey, Herts

The news reports just mentioned show that when unprotected houses are struck, people are injured or killed in almost every conceivable location in the house. It seems that there is no place in a house to which lightning will not penetrate, although many statements to the contrary have been made. Some places in a house are undoubtedly more dangerous than others, however, among such places being the vicinity of stoves, places between masses of metal on the exterior of the building, and metallic masses on the interior of the building, whether earthed or not, and near chimneys. An example of a place between metallic masses of the character of those just mentioned would be between a down spout and a steam or hot-water radiator. Other dangerous places in a house during a thunderstorm are at telephones, or touching screen doors or other metallic bodies which connect with the exterior of the building.

Out of doors the most dangerous places are evidently in open fields, under isolated trees, and near wire fences. Small sheds and other shelters are almost equally as dangerous as isolated trees, especially if the sheds are in the open, away from larger buildings. Thick timber is undoubtedly the safest place to seek out of doors, for the reason that a single tree under which a person might take shelter in a forest area is not as likely to receive a stroke as a single object of a person in an open space of equal area.—*Technological Papers No. 56 of the Bureau of Standards.*

Photographic Determination of Auroral Heights

IN a series of communications to *Terrestrial Magnetism*, Prof. Carl Störmer, of Christiania, has described his photographic determination of auroral heights made in 1913. An account of the earlier communications has already appeared in *Nature*. The two most recent papers of the series, appearing in March and September, 1917, give an account of Prof. Störmer's theoretical investigations. In a brief historical note he assigns to Goldstein the distinction of having been the fir t to suggest that an electrical discharge from the sun is the common cause of aurora and magnetic storms. The mathematical problem which Prof. Störmer has set himself treats the earth as an elementary magnet, and as the sole source of a magnetic field traversed by electric corpuscles. A complete solution has not been found even of this simplified problem, but trajectories can be calculated by graphical and numerical integration, and conclusions as to the limiting forms of trajectories can be derived from the general equations. Prof. Störmer accepts for the observed angular radius of the zone of maximum auroral frequency 23 degrees. The values given by his calculations are, for cathode rays 2 degrees to 4 degrees, for β rays 4 degrees to 6 degrees, and for α rays 16 degrees to 19 degrees. The calculated values assume, for the respective rays, such properties as have been actually observed in the laboratory. Prof. Birkeland, the chief supporter of the negative corpuscle theory, suggested to meet the difficulty, that corpuscles from the sun had velocities very closely approaching that of light. Prof. Störmer thinks it makes fewer claims on the imagination to attribute aurora to α rays, the theory advocated by Vegard. The occasional appearance of aurora far outside the auroral zone is, he admits, a serious difficulty; but he suggests that during magnetic storms the earth may be encircled by a corpuscular ring of large radius, whose modification of the magnetic field may suffice to bring α rays emanating from the sun much nearer the equator than would otherwise be the case. The measurement of auroral streamers is looked to as likely to elucidate at once the penetrating quality of the rays and the constitution and temperature of the upper atmosphere. Prof. Störmer refers to the sun's magnetic field and an electric charge as considerable complications of the mathematical problem.—*Nature.*

The Sikhs—II*

A Sect That Became a Nation

By Sirdar Daljit Singh, C.S.I., Member of the Council of the Secretary of the State of India

[Concluded from Scientific American Supplement No. 2204, Page 208, March 30, 1918]

INSTITUTION OF THE PAHUL

I pass over the years of Guru Govind Singh's preparation for conflict, and come to that most important event in the history of the Sikhs which is known as the Great Test, and to the organization of the "Khalsa." Determined to evolve out of this religiously united people a nation of warriors, he called a huge meeting of the Sikhs on the first of Baisakh (April 12th), 1698. It was drawn from all parts of the Province and it met in an extensive plain, in the midst of profuse verdure, in one of those beautiful valleys which lie at the foot of the lower range of the Himalayas. Out of a tent pitched in one corner appeared the Guru with a drawn sword in his hand, and demanded for the establishment of the kingdom of righteousness the head of one of his Sikhs to be sacrificed. A man instantly arose, and with folded hands said, "Yes, O Lord, I am at your service. Do with me as you please." This brave soul was Daya Singh, a Kshattriya by caste. The Guru led him inside the tent. A moment later he appeared again with the sword dripping blood. When he demanded another head the ordeal was of the severest; yet a second man, Dharma Singh, responded to the call. Three times more the Guru made his demand, and three more heroes offered themselves—Himmat Singh, Mohkar Singh, and Sahib Singh, all three of low caste. There were many others ready to sacrifice their lives for the true cause, but the Guru did not appear again. Soon afterwards the curtains of the tent were drawn back, and, to the great astonishment of the assembly, there stood revealed the five chosen ones, typical of that region of five rivers of which the Punjab was to be formed. Addressing the multitude, the Guru said: "Heaven is but a property of noble souls like these; nevertheless there is work for them yet in this world. I wished to find out, in the presence of a full meeting of my Sikhs, what each individual was capable of; and we have found that out."

This ordeal was followed by a great Durbar, in which the first ceremony of the Pahul baptism was performed. An iron vessel was brought, some water and sugar were put into it, and these were stirred with the point of the sword while the Japji and a composition of the sayings of Guru Govind Singh were recited. The Guru called this mixture *shirbatt*, as Amrita—ambrosia. Some of it was sprinkled on the heads of those first five, and the rest was drunk. Then he in turn had himself baptised by the fire. In virtue of this ceremony they became members of an equal brotherhood: and they were invested with swords, and stood vowed to their faith as sons of the Guru. The spirit of their Guru had entered into them. By companies of five, all who offered themselves were afterwards inaugurated: they were hailed as Singhs, or lions, warriors or Kshattriyas without distinction of caste, a name which had been used by Hindu Kshattriyas or warrior caste alone; and thus was formed the Khalsa, or fighting commonwealth of the Sikh nation. In less than a fortnight 80,000 Sikhs had flocked around the Guru as Singh. Later on a few Mohammedans and a large number belonging to the low caste considered as "untouchable" amongst Hindus were also baptised. The fact that even under the circumstances a few Mohammedans accepted the religion is remarkable when arms were used for conversion to the faith of the rulers. His purpose and the pure creed of Guru Nanak were proclaimed in an eloquent exhortation; and, by way of marking a clear outward distinction from Mohammedans and Hindus alike, not only were certain customs and insignia forbidden to them, but as warriors they were enjoined to wear "the five K's"—namely, the *kes*, or uncut hair; the *kripan*, or dagger; the *kanga*, or comb; the *kuchh*, or short breeches ending at the knee; and the *kara*, or iron bangle. They were to worship neither idols nor the dead, no Hindu tomb and no grave, and abstain from the use of tobacco. Finally, they were to greet each other with a special salutation, meaning "The Khalsa is of God and His is the victory."

GOVIND SINGH'S ACHIEVEMENT

This was the starting-point of the Sikh nation. Govind Singh had created a force which soon proved formidable, even against the might of Aurangzeb. In the course of more than thirty years, during which he was the spiritual head of the Sikhs, he commanded in many battles and won some signal victories, which led to the rise of the Khalsa as a commonwealth and a power, and were one cause of the fall of the Moghul Empire. Historians all agree upon his genius. He was the greatest teacher and reformer of his age, a great organizer and leader in war, and an ideal of self sacrifice, self-denial, and modesty in his relations with the brotherhood he had created. It is said that a Sikh once brought to the Guru, as a gift, a pair of wristlets set with precious stones, worth a hundred thousand rupees. Govind Singh would not accept the offering. At the moment he was seated on the bank of a river, and on the Sikh insisting he put the jewels on, but a few minutes later dropped one of the wristlets into the stream. Anxious for its value, the devoted Sikh announced a reward of a thousand rupees for any man who should recover it. A diver came forward. Before entering the water this man asked the Guru to point out the exact spot where it had fallen; and thereupon Govind Singh, by way of doing so, cast in the other wristlet after it. As for the spirit of self-sacrifice, we have seen how it appeared in him under the test of his father. And what sacrifices could be greater than he suffered in the loss of his four sons? When that unhappy event reached his ears by which two of the younger were buried alive at Sirhind, not a single tear was seen in his eyes, and the only words he uttered were, "Thy will be done." This most cruel episode was never forgotten by the Sikhs; and Sirhind was for a long time the chief point of their warlike attacks, until it was finally conquered and destroyed. The original town still forms a part of Patiala State. The fact is a sufficient confutation of the vulgar fiction that the purpose of Sikh belligerency was plunder. They, too, exhibited the spirit of self-sacrifice. Govind Singh had so conspicuously imparted it to his followers that, with regard to certain Sikhs whose skin and flesh were torn by executioners under the orders, a Mohammedan writer says: "It is singular that these people not only behaved firmly during the execution, but they would dispute and wrangle with each other who should suffer first; and they made interest with the executioner to obtain the preference." In the battlefield every Sikh bore himself fearlessly, repeating the saying of the Guru:

> O Lord, give me only this blessing, that I may never go back from doing virtuous acts . . .
> And when I go into the field that I may be killed there, and my firm belief be in victory.

Such was the national spirit created by Guru Govind Singh, and yet of these followers he said:

> Verily I am but one adorned by them; otherwise there are millions of poor men like myself.

Besides all this, I have to complete his picture by a reference to fostering services to the Hindi and Punjabi languages. He was an excellent poet of Hindi as well as Persian. In Persian he wrote the famous letter in verse to Aurangzeb known as "Zuffer Nama." In Hindi there are a few books and a good many verses written by him. He was so fond of poetry that he had always with him a school of poets, who translated numerous Hindu Shastras and some Persian manuscripts into Hindi verse to make a literature of their own. The Granth of the tenth Guru contains all such poetical works. It is notable that music and poetry have been so intrinsic to the religion that these arts are a predominant feature of all the Sikh ruling courts.

The last of the Gurus died peacefully in 1708, in the midst of his devotions at Nadir in the territory of H. H. the Nizam, where later Maharaja Ranjit Singh erected the tomb, and H. H. the Nizam's Government assigned a sumptuous Jagir for the upkeep of the same. The value of his Pahul was to be recognized in due time by the British Government, when it was made compulsory upon all Sikhs entering the Indian army; and I desire at once to acknowledge that this recognition has been largely instrumental in maintaining the spirit of the nation.

RISE OF THE KHALSA

On the death of Guru Govind Singh, the Khalsa was led by an intrepid warrior named Banda, who for a time made himself master of the region between the Sutlej and the Jumna. But it is chiefly important to note the rise of that organization. Guru Govind had said: "The Khalsa arose from the Guru, and the Guru from the Khalsa." Again: "The Guru shall dwell with the Khalsa; and wherever there shall be five Sikhs gathered together there shall the Guru be also present." There came into existence a sort of a system of a cabinet or national council, which, having been founded by Guru Govind himself, with a quorum of five, replaced his personal authority in it, and which sometimes elected a leader called the Jathaidar. When this met the Khalsa had an opportunity of expressing their feeling as to current events; and the cabinet's decision was known as the Guru Mata. Sir Charles Malcolm says of the institution of this cabinet and the Guru Mata that: "It furnishes a fresh proof of the comprehensive and able mind of this bold reformer, who gave by its foundation that form of a federative republic to the commonwealth of the Sikhs * * * by giving them a personal share in the government and placing within the reach of every individual the attainment of rank and influence in the State." There is a significant story of the election of a Jathaidar, Kapur Singh, and the high appreciation for the sense of justice shedding a humane light upon a period of cruel trial. The national council being assembled, it was said: "We should elect such a man as will see all parties with the same eye." In a recent battle Kapur Singh, carrying a waterskin, had been seen giving drink to the wounded, and it had been noted with admiration that in doing so he did not distinguish between a Sikh and a Mohammedan. He was elected for this magnanimity. But it is to the second of such chosen leaders, Jassa Singh, with his contemporary Ala Singh, that the credit of actually founding the kingdom of the Punjab must be given. The Sikh commonwealth at this time was divided into twelve families, clans or *misls* as they were called, and Jassa Singh, belonging to one of these, held together a confederacy on the northern side of the River Sutlej; while Ala Singh stood in a similar relation to the *misls* of what are now known as the Phulkian States on the southern side. Jassa Singh, the founder of the ruling house of Kapurthala, now the premier ruling State on the trans-Sutlej side of the Punjab, commanded universal respect among the Sikhs; and even the family of Ala Singh considered it an honor to be baptised at his hands. His was a great achievement. Compared with the romance, the bloodshed and the heroism of that period, there is nothing in the history of Scotland before the Union that can be considered on the same scale, for Scotland had but only a single though an inveterate enemy, but the Punjab was the high road of every foreign invader and the first brunt of the onset fell upon the Sikhs.

THE KINGDOM FOUNDED

Jassa Singh's outstanding bravery and political skill founded the kingdom of the Khalsa at Lahore in 1753. And for the first time coin of Khalsa was struck in the mint of the Moghuls, bearing the inscription. "Coined by the grace of the Khalsa in the country of Ahmud, conquered by Jassa the Kalial"; and he was the first ruler to be called by the Sikhs their king. Thus the force created by the genius of Guru Govind Singh began to come into its own, and even the relentless energy of Nadir Shah and Ahmad Shah Durrani could not subdue it. It was at this time that the Golden Temple was rebuilt at Amritsar.

RANJIT SINGH

On the foundation laid by Jassa Singh, Ranjit Singh, the Lion of the Punjab—who began to rule at Lahore in 1799—built the complete sovereignty. The policy of Maharaja Ranjit Singh, who belonged to the Sukarchakia *misl*, is notable in these respects—that among the officials of his Court, high and low, he had both Hindus, Mohammedans and Sikhs; that in his armies there were officers and men of all ranks belonging to the three religions; and even Europeans. By the end of 1834 he had not left a trace of Afghan authority east of the Indus, and rules over a kingdom with an area of some 145,000 square miles.

At the time of Ranjit Singh's accession only three

*Abstracts from a paper read before the Royal Society of Arts, and published in the Journal of the Society.

misls commanded much influence. On the northern side of Sutlej two of them had founded independent States, namely, the kingdom of Lahore and Kapurthala, the latter ruled by Fateh Singh, a descendant of the great Jassa Singh and a chieftain of whom Sir Charles Metcalfe said that he was "the equal, if not the superior, of Ranjit Singh in rank and power." The third, on the southern side, had founded under Ala Singh the State of Patiala, together with the States of Nabha and Jindh, known as the Phulkian States. When Ranjit Singh was on the threshold of his career, in 1806, the East India Company became involved in the second Mahratta war, and these three States were perhaps the first in Northern India to make alliances with the company. There you saw the effect of the prophecy uttered by Guru Tegh Bahadur. The result of these alliances, and of the rout of Jaswant Rao Holkar, the Mahratta chief, was to free the hands of Ranjit Singh for those campaigns in which, with the powerful aid of Fateh Singh, he wrested the provinces of Multan, Kashmir and Peshawar from the Afghans.

ANNEXATION AND MUTINY

After the death of Ranjit Singh a state of anarchy prevailed in the Kingdom of Lahore, and constant troubles obliged the British administration to annex that kingdom, while the other States continued to exist independently. The policy of Lord Dalhousie by admitting them to the British Army as valorous friends, and the trust thus placed in them, enlisted the martial spirit of the Sikhs almost immediately on the side of the British. By some critics this policy was questioned; but in 1857 the Mutiny put it to a supreme test, and the Khalsa did not waver. The Kapurthala and Phulkian chiefs were the first leaders to take the field against the mutineers, and their example was followed throughout Punjab. Sir Lepel Griffin acknowledges freely that they acted "on the very first alarm, and without waiting to see whether the omens were auspicious or hostile." The promptness and entire devotion of the Patiala and Kapurthala chiefs have, I believe, endeared their memory in particular not only to Englishmen, but to all Indians who appreciate the blessings of peace, prosperity, and freedom. They put all their resources, without reserve, at the disposal of the British authorities, and when the Punjab declared itself on the same side the issue ceased to be doubtful. To the mutineers the fall of Delhi was a death-blow. When you consider that eleven years only had passed since the annexation, and that this had been preceded by two wars, I do not think you will underestimate such a proof of attachment and spontaneous loyalty.

THE SIKH CIVILIZATION

Let me sketch, briefly, the civilization which had begun to shape itself among the Sikhs at this time. Sikhism is eminently a literary religion. As we have seen, the Sacred Book compiled by the fifth Guru, and supplemented by the ninth, contains hymns of singular beauty, the singing of which forms the most important part of our worship. They are mostly in Punjabi, though the hymns of Guru Nanak include a number in Rajasthani and Sindhi, and a few in Persian. The original manuscript is preserved at Kartarpur, in my own district. This Sacred Book, carried at the head of all Sikh regiments, is considered as a living Guru. Besides this sacred volume, the sayings and works of Guru Govind Singh, and the compositions of all his chief poets, are collected in another book, which is generally spoken of as the Granth of the tenth Guru. They include not only hymns, but regular compositions in the language of Hindi classical verse. A system of education introduced by the Gurus is noteworthy. In connection with religious centers called Dharmsalas, established in every town, and even in every village where the majority of the population were Sikhs, there was a learned teacher whose duty it was to impart secular as well as religious instruction. This system corresponded to what in modern times is called free primary education. There was also a system of tribunals, the Panchayats, deriving its name from the quorum of five or "Punch" fixed by the Guru for the National Cabinet, a system which the British Government has lately been disposed to revive. The functions of this tribunal were civil and judicial. But the greatest proof and test of our civilization is its social effects throughout the Province. It is only in the Punjab that you may see today a free intercourse between Hindus and Mohammedans in eating and drinking, and that the social life is cosmopolitan. Whereas, indeed, even a Brahmin of one province will not eat with a Brahmin of another province, and elsewhere one man fears to be defiled by another's shadow.

ART

Of our arts, the chief example is the Golden Temple. How shall I describe that glory of architecture? It stands four-square, reflected on all sides in the waters of the sacred pool, a shining splendor of gold and marble. A marble gate and bridge form its noble approaches. From the picture I show, you will see that the style is Mohammedan, with Hindu details, and that the high plinth is of marble, with a golden superstructure topped by minarets. In this temple only the Sacred Book is read, and the orisons for dawn and sundown are daily sung. As the light of each day breaks there are thousands of worshippers, from the poorest to the richest, waiting to hear the first verse when the Book is opened. The scene is wonderfully solemn and uplifting. Then consider the historic interest of the temple's surroundings. On the outer margin of the pool there are houses built by the *misls* and by other leading men of the past. Devotees come and sit between this façade of houses and the water, where a broad marble path goes round the "Pool of Immortality." The temple is radiant under the Indian sun. And when the pool is illuminated with floating lamps for the Dewali Festival, and you see it gleaming beneath a canopy of stars, it leaves one of those ineffaceable memories which all men cherish.

THE DOMINIONS

Just a word to compare the Sikh dominions as a whole with the present Province of Punjab. As I have said, the Sikh dominions extended from Delhi to the Khyber Pass, and from Multan to the Kara Koram Mountains. It included the States of Jammu and Kashmir, the district of Hazara, Kohat and Bannu, and also the district of Derajat. The whole cis-Sutlej side was under the rule of the descendants of Phul. On the northern, or trans-Sutlej side, a part of the Ludhiana, Jalandar, Ferozpur and Amritsar districts was under that of the Kapurthala house, descendants of Jassa Singh; while the rest was known as the Lahore Kingdom under Maharaja Ranjit Singh's government. As it now stands, the whole region is divided into three parts. Two, the Punjab proper and the Northwest Frontier Province, are under British administration, while the third forms the State of Jammu and Kashmir.

STATES

Within the States administered by the British Government, the Phulkian and Kapurthala houses still enjoy their ruling powers; and two more ruling States, though much smaller, are recognized besides, *viz.*, Faridkot on the trans-Sutlej side and Kalsia on the other. The total area of these various ruling States is about ten thousand square miles, and their military strength is seven thousand with 152 guns. This, from the Mutiny down to the present world crisis, has always in time of need been put at the disposal of the Government, together with every other resource of these independent States.

ARISTOCRACY

Besides the ruling houses, there were at the time of the annexation a host of smaller chiefs or large landholders, Jagirdars, together with some nobles of Ranjit Singh's court. They now enjoy nearly the same privileges, forming the famous aristocracy of the Punjab. They are the social and political leaders of the Province and have never failed to serve in times of war and peace alike.

Optical Properties of Light-filters

THE optical effects produced by the use of color filters may be divided into two classes. The first class includes those resulting from the use of a theoretically perfect filter; the second, those which result from imperfections occurring in the filters—that is, from departures from the conditions of plane parallelism in the faces and of equality in thickness between the three filters of a set. The effect of a plane-parallel filter on the aberrations of a lens-system is considered first. Suppose that a plane-parallel piece of glass is placed in front of a lens, then it will produce upon the oblique rays a displacement compared with the axial beam which will result in two effects: (*a*) it will give rise to a species of spherical aberration all over the field, causing the marginal rays of each image-forming pencil to focus at a greater distance from the lens than its central ray; and (*b*) on account of the tendency of a small oblique pencil to foreshorten abnormally in the object plane, the image plane will be curved backward. These displacements are greatest when the obliquity of the rays is greatest; they also depend upon the thickness of the filters. The spherical aberration and curvature of field produced by interposing in front of the objective a filter 15 mm. thick and of index of refraction 1.55 is worked out, given a process lens working at F/6.3, of 16 in. focal length, taking a picture 10 X 12 in., forming an image half the size of the object.

The effect of a set of perfect filters is next dealt with, If for the three colors we use filters of the same thickness, then we shall obtain a difference in the size of the images produced owing to differences in the refractive index of the glass for different colors of light; that is to say, the effective thickness will be altered by the dispersion of the glass. The amount of this can be calculated for a given glass, knowing its refractive index and dispersion. For a typical glass used for filters, and taking a filter thickness of 15 mm., the difference in refractive index between the red and the green was 0.068 and between the green and the blue 0.0159, which gave an effective difference of path between red and green of 0.043 mm. and between red and blue of 0.142 mm. Such a filter will not be used with a smaller optical path than 50 cm., and in general if used in front of the lens, the distance from the object plane to the nodal plane of the lens will be 1 m. or more and the effect will therefore produce a difference in size between the red and blue images of the order of one part in 5,000, an amount which is much smaller than the resolving power of the half-tone screen used in photo-engraving and, in practice, is indistinguishable. The effects upon the definition and size of image that are introduced by the use of filters which are imperfect, either in plane parallelism of surface or in equality of thickness, in a set of filters are naturally more complicated than those which result from the use of perfect filters. Since the errors of surface may be of any type—wavy, spherical, wedged, or cylindrical—the investigation of the effects produced can only be performed experimentally. When a proper experimental method had been worked out it was found that some filters which gave quite perfect images with lenses appeared poor in an interference test, while other glasses which showed up much better in the interference test were useless for the purpose of light filters upon long-focus lenses. This being so, it was found necessary to test the filter by the observation of its effect upon a lens image. The differences in the size of the images produced by a set of three color-filters which differ slightly in thickness and also in focal length due to cylinderical or spherical curvature of the faces, might be thought to be subject to accurate calculation, but the effects are so complicated that it was found desirable to design an instrument for directly measuring these differences. An instrument was therefore constructed in which a lens of about 25 cm. focal length formed two images about 20 cm. apart of two cross-hairs, the distance between the images being measured by means of microscopes mounted on carriages actuated by micrometer screws. The various filters could therefore be placed over the lens, and the effect of the filter upon the size of image could be directly determined and compared with the amount calculated from the focal length and the thickness. The results obtained with this apparatus are given. It is further noted that two filters may be of the same power, but if in one filter the front surface is curved and in the other the back, this will produce a shift in the noda' point of the filter of about its own thickness, and a difference of size of image. From a paper by C. E. K. MEES, in Eastman Kodak Co.'s Research Lab., *Abridged Science Publ.* 2, No. 41.

Government Department of Inventions in France

A CONSIDERABLE effort is being made in France to call into use all the available inventive skill with a view of solving the numerous problems that are now presenting themselves, both in war operations and in industrial efficiency. A Government Department of Inventions has recently been organized and it will act as a central point. Not long since, the department issued an appeal to inventors or scientists to lend their aid in the way of finding solutions for the food as well as the heating problem, and all inventions or ideas will be given due attention which are likely to give better efficiency in the utilization of alimentary products and combustible matter or to afford better methods of use, or again to prevent waste of such material.

The Most Practical Accelerator of Vulcanization

EXAMINATION of an accelerator placed on the market by a German firm before the war, showed it to be dimethylamine dimethylaminodithiocarbamate. The method of preparation of this substance by the formation of dimethylamine by the action of a four per cent solution of potassium hydroxide on *p*-nitrosodimethylaniline and its further combination with carbon bisulphide to form the desired product is outlined; the cost of the materials required for these processes is estimated to be about 4.5 fr. per kilo. (pre-war prices). Using one per cent of this accelerator in a rubber mixing the duration of the vulcanization process is stated to be reduced in the proportion of 8.3.—Note in *Jour. Soc. Chem. Ind.* on an article by A. HUTIN in *Monit Scient.*

A Simple Line-Dividing Instrument

By A. Bursill, B.Sc. (Eng.), A. M. I. E. E.

IT is frequently necessary in drawing-office work to divide a line into a given number of equal parts, or to divide a line in a given ratio. When the line is of such length that its measure is readily divisible by the required number of parts, the draughtsman generally adopts the plan of finding the length of the part by arithmetical division, and measuring it off by means of his scale. Very often it happens, however, that the measure is not readily divisible, and the draughtsman is then compelled either to use a geometrical construction, to find the approximate length of the part by arithmetic, or to find the required part by trial with the aid of a pair of dividers. The last, and least scientific, method is probably used most frequently in practice, owing to the natural tendency for a workman to use the tools most readily to hand in carrying out his work.

The purpose of this article is to describe a simple instrument which enables the subdivision of a straight line to be carried out by the geometrical method with great facility and in a minimum of time.

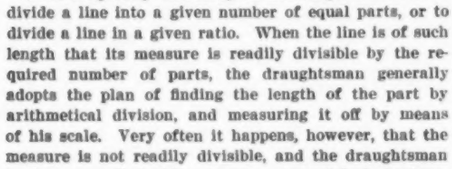


Fig. 1

Suppose it is required to subdivide the line AB (see Figure 1), of length, say, four inches, into seven equal parts; then the well-known construction is as follows. Draw the line AC of any length and at any angle to AB. From A cut off seven equal parts of any length along AC. Join the last point D to B, and from each of the other points draw lines parallel to DB, and cutting the line AB. These lines will divide the line AB into the required number of equal parts.

Now it is clear that the same result could have been obtained if a series of equidistant lines had been drawn on tracing paper and adjusted to AB, so that line No. 0 passed through A, and line No. 7 through B. The points of division could have been then pricked through the tracing paper.

The instrument devised by the present writer can be used to carry out the division even more readily, and certainly more accurately, than the tracing paper. It consists, in its simplest form, of a sheet of celluloid formed into a series of equidistant parallel straight-edges by having a number of slots cut in it. The straight-edges are bevelled to make drawing more convenient, and the last of the series is one of the bounding edges of the celluloid sheet.

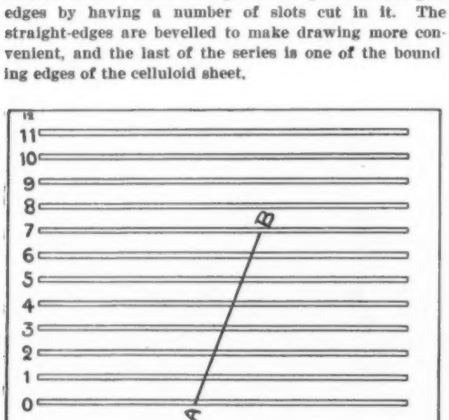


Fig. 2

In Figure 2 the instrument is shown dividing the line AB into several equal parts. In order to do this the point of the pencil is put through slot No. 0 and placed upon the extremity A. The edge No. 0 is then pressed against the pencil point, and the line-divided rotated until edge No. 7 passes through B, due allowance being made however, for the thickness of the pencil point. The instrument is then held firmly in position, and the pencil drawn along edge No. 7. If the line so made passes through the point B, the correct allowance has been made for the thickness of the pencil point. After testing, to see that this is so, the other points of division are marked on the line at the appropriate straight-edges.

By omitting all other marks except that at edge No. 3, the line is at once divided in the ratio 3 : 4, and, nafurally, the line can be divided in other simple ratios in a smaller manner. It will readily be seen that a line may be divided either internally or externally by the aid of the intrument.

The instrument shown in Figure 2 is of rectangular form (18×13.5 centimeters), and the distance between consecutive working edges is one centimeter, the length of each edge being fifteen centimeters, so that the maximum length of line that can be dealt with is $\sqrt{15^2+12^2}$, or just over nineteen centimeters, and such a line can be divided into twelve equal parts. Of course, the shortest division that can be obtained in any case will be the distance between consecutive straight-edges—in this case one centimeter. It follows, therefore, that an instrument of this particular design has a somewhat limited range of usefulness, and it has been described, first, because it will render the method of use of a slightly more complex instrument almost self-evident, and because of its educational value in illustrating the geometrical principles involved to young students.

In the rectangular form, the range of the instrument cannot be very extensive, owing to mechanical considerations. Thus, to make the possible length of line a maximum, the edges must be as long as possible; and to make the least division as short as possible the bars must be narrow. Both these methods of increasing the range tend to make the bars flexible, and cause inaccuracy and possibility of breakage.

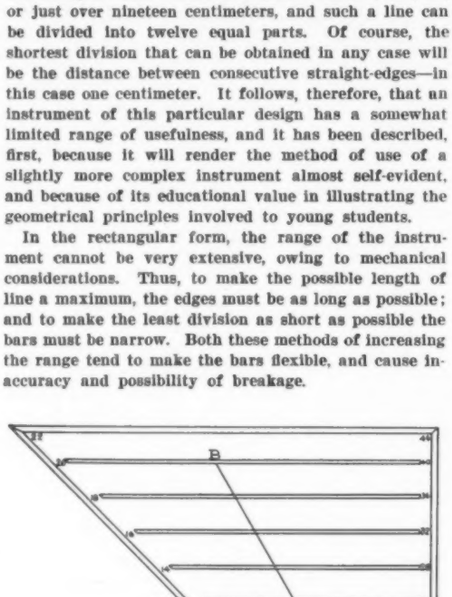


Fig. 3

In order to obviate these difficulties, the drawing-office type of line-divider is made in the form of a forty-five-degree set-square, having the two equal edges 24.5 centimeters each. The edges from 0 to 5 (see Figure 3) are a half-centimeter apart, from 5 to 12 are one centimeter apart, and the remaining edges, which are long and must have considerable strength, are separated by two centimeters. In this way the bars are all of great rigidity, so that accuracy is obtained. It is not, of course, absolutely essential for the instrument to be made of celluloid; but it is advisable, on account of the greatly increased facility of use if it is made transparent.

With the final design of line-divider shown, the greatest length of line divisible is thirty-one centimeters, and the shortest length of division is half a centimeter. The diagram shows a line AB, of length twenty-three centimeters, being divided into ten equal parts. It will be noticed that in this position the point C divides the line in the ratio 9:31, which would be difficult to do with both speed and accuracy without the use of the line-divider.—*Knowledge.*

The Mont d'Or Tunnel

THE Mont d'Or Tunnel, built in the years 1910 to 1915, was planned more than 30 years ago, but the problems were not seriously approached until after the completion of the Simplon Tunnel. The tunnel is on the line from Frasne, in France, to Vallorbe, in Switzerland, and it was projected in order to shorten the international railway route by the "ligne de Jougne," which has been built as a makeshift in 1871, by 20 km., to reduce the gradients of 25 per mile maximum, and to lower the culminating point from 1,012 m. down to 894 m. above sea level. The Mount d'Or forms the northeastern end, between Longueville and Jougne in France, and Vallorbe in Switzerland, of a ridge which extends parallel to the frontier on French territory, and reaches a height of 1,463 m. The tunnel runs from Longueville (level, 894 m.) in a length of 6,097 m., with a gradient of 13 per mile, down to Vallorbe (816 m.): five-sixths of the tunnel are rectilinear, only the entrance to Vallorbe is curved, being an arc of 685 m. length (radius of curvature, 700 m.). The water caused very serious difficulties during the operations, and it is to these and to their geological character, that Dr. H. Schardt, of Zürich, devotes a series of four articles in the December numbers of the *Schweizerische Bauzeitung*. The smooth folding of the surface formation did not suggest any particular distortions and water troubles. When operations began in November, 1910, on the Swiss side, from which most of the work was done, and in June, 1911, from the French side, the disclosed stratifications, though not badly distorted, and the character of the limestone and marls, prepared the engineers for inrushes of water. The troubles were far worse than expected, however, in the fifth group of sources, which was struck in December, 1912, at 4,273 m., from Vallorbe. A cleft, about 60 cm. wide, filled with a yellow loam, did not at first discharge water. When the tunnel had been pushed 93 m. further, however, this loam, which had gradually become soft, was driven out, and water burst into the tunnel at the rate of about 3,000 liters per second. The tunnel was flooded, and a great washout occurred at the Vallorbe end. On the same day, one of three springs, lying about 5 km. northeast of the tunnel, at levels from 79 to 84 m. higher than the tunnel, began to run dry, and the other two stopped two days later. The builders were faced with claims for heavy damage done, not only by the flood, but also by the tapping of these sources. When the inrush of water quieted down, the water was temporarily deflected through the ventilation conduit, the cleft was stopped below, and the whole tunnel was barred at the spot by a concrete dam, through which two pipes were laid, one supplied with a valve. The valve was closed on January 19th; the water pressure rose, first rapidly, then more slowly and irregularly; within 48 hours the first of the three springs began to flow again, and the others followed. In order to trace the water current, fluorescein was added to the water; this was successful, though the fluorescein did not rise in the quiet water behind the dam. Later the dam was removed again by blasting: the advance had not proceeded far, however, when, at 4,407 m. from Vallorbe, a drill was shot out of its hole, and water again flooded the tunnel, this time at the rate of 10,000 liters (over 2,000 gallons) per second. The new springs and the old ones, it was found afterwards, were interconnected by some channel underneath the tunnel. All the difficulties were, however, overcome, and the tunnel was opened in 1915. Finally, out in the open, between Longueville and l'Abergement, a great moor had to be crossed by the railway. This moor forms the ancient basin of two lakes which are now joined by the Doubs River. A viaduct, 360 m. in length, was first planned; but soundings down to depths of 65 m. found no rock bottom. Then a bank was built, which, sinking, pressed the ground near it up, and it proved clear that the Doubs would have to be deflected in a curve, so that it might be bridged on rocky ground. As the rock was wanted for building the dam, and as there were level difficulties, the new course of the Doubs had partly to be made subterranean. In the middle of the lake the embankment subsided altogether by fully 40 m., and the track had to be relaid several times.—*Engineering.*

Solar Hydrogen Bombs

A REMARKABLE solar phenomenon of short duration has been investigated photographically and visually by Mr. F. Ellerman at the Mt. Wilson Observatory (*Astrophysical Journal*). It consists of the sudden appearance of a very brilliant narrow band extending for several angstroms on each side of H*a*, which persists as a dark line with little change in width. The duration is only from one to three minutes on the average, and rarly from five to ten minutes. The average width of the bright band is about 8 A., but in an extreme case the band extended over 30 A. These "bombs" are most likely to appear around and among active spot-groups, especially groups which are developing and have many component members. At times they follow one another like the balls of a Roman candle, at intervals varying from ten to twenty minutes. Two essential conditions for their observation are good seeing and a large solar image. The appearance suggests something of the nature of an explosion, in which nothing but hydrogen seems to be involved. The level at which the explosions occur would seem to lie below the reversing layer, as the Fraunhofer lines, including those of hydrogen, do not seem to be affected. The phenomenon is quite distinct from the ordinary eruptive reversals of H, in which the continuity of the dark line is interrupted.

Notes on a High Temperature Thermostat*

By J. L. Haughton M.Sc., and D. Hanson, M.Sc.
(Both of the National Physical Laboratory.)

In a former paper read before this Institute,[1] the authors described a thermostat for moderate and high temperatures, but the apparatus there referred to was made of glass, and its use was therefore limited to temperatures not exceeding 500 deg. Cent. The object of the present paper is to describe certain alterations which have been made in the apparatus to render it suitable for much higher temperatures, and to extend its usefulness in other directions. In principle, the instrument consists of a double-walled vessel A—Fig. 1—similar in shape to a Bunsen ice calorimeter, which is made into a furnace by winding it with nichrome wire. This vessel acts as a gas thermometer, and the variations in the pressure of the air contained in it are used to operate a contact breaker, B, which increases or decreases the current supplied to the furnace, according as the temperature falls below or rises above the desired value. The contact breaker takes the form of a U-tube, containing mercury, fitted with two platinum contacts, which breaks the relatively small current of a "solenoid" relay, E; this in turn pulls a fork into, or out of, two mercury cups, by means of which an external resistance, D, is cut out of, or put into, the furnace circuit. One side of this relay is connected to the furnace bulb, A, and the other is connected to the closed bulb of another thermostat, C, similar in principle to the main thermostat, but of much simpler construction; this device, of which a detailed description is given in the paper, being necessary to render the instrument immune from the variations which would otherwise be caused by changes of atmospheric temperature and pressure. Further to extend the applicability of the thermostat to metallurgical work, a device, H, has been added, by means of which extremely slow rates of cooling or heating can be obtained, if necessary, of the order of 1 deg. or 2 deg. Cent. in a day.

Various attempts were made to overcome irregularity in action caused by the expansion of the mercury in the U-tube B—Fig. 1—and success was reached when the tube was made of fairly large diameter, and but little mercury was used. A U-tube of this form has the further advantage that it acts as a shifting valve in case of a vacuum being formed in A and allows air to be drawn in.

As originally made, the cold bulb was immersed in a pint size thermos flask, which it was not far from filling, the remainder of the space being filled with ice. As the ice melted, the top of the bulb became more and more uncovered, and and the air inside rose gradually in temperature, with a resulting rise of temperature in the furnace itself. A new form of cold bulb was therefore designed in which the principles of the main furnace were embodied. It is seen in section at C—Fig. 1. The regulating fluid was used as a "lagging" round the mass whose temperature it was required to keep constant, and was placed between it and the source of heat. This thermostat consists of three concentric cylinders, arranged as shown. The inner one acts as the air bulb of the thermostat and is surrounded by benzene, contained in the middle cylinder on which the high-resistance heating wire is wound. The benzene acts as an expanding liquid, and operates the mercury contact breaker in the U-tube, while in this case also the full current is broken in the benzene, which appears to be undecomposed by the spark, and the surface of the mercury keeps quite clean. The third cylinder contains thermal insulation. This apparatus has proved very satisfactory in use, and it has not been found possible to detect, by means of a thermocouple inserted in the central tube, a change as great as 0.1 deg. Cent. in the temperature.

While the maintenance of a constant temperature is a matter of great importance in many operations, it is sometimes desired to obtain extremely slow cooling over a limited range of temperature, as, for example, through a thermal critical point. For this purpose, after several other attempts had been made, it was decided, the fact already observed, that by using a very poor thermos flask in which to keep the cold bulb, a slow rise of temperature was obtained in the bulb, and consequently in the thermostat. If, then, a gradual fall of temperature could be obtained in the cold bulb, it would be accompanied by a corresponding fall in the furnace itself. It would, of course, be possible to do this by immersing the bulb in a thermos flask containing water at a higher temperature than that of the atmosphere, but there are certain drawbacks to this method. If the rate of cooling in the furnace is to be very slow, the fall in the thermos flask must also be slow—*i. e.*, the water must be near room temperature. Under these circumstances, the rate of cooling will fall off rapidly as the water approaches room temperature, and the cooling of the furnace will not be uniform, while the effects due to changes of room temperature will be increased. On the other hand, if the water in the thermos flask is sufficiently above room temperature to make the fall reasonably uniform over the whole of the period, the rate of cooling becomes excessive. To overcome this a subsidiary, but very much smaller, bulb, H, was inserted in parallel with the cold bulb, and immersed in hot water in a thermos flask, so that but a fraction of the total air was cooled. In this way the change in the pressure of air in the cold bulb side of the apparatus could be varied between very wide limits, with corresponding variations in the rate of fall of the temperature in the furnace, merely by altering the volume of the controlling bulb, while the fall in the furnace is made independent of the actual fall in the thermos flask. By using a very small bulb a fall of 1 deg. Cent. per day has been attained, but as 1 deg. Cent. is about the limit of accuracy of the thermostat, the temperature during such a run may be stationary, or even rising, for an hour or more. If it is required to continue the slow cooling over a considerable range of temperature, the subsidiary bulb is put into communication with the atmosphere by means of a two-way tap—*h*2—while the hot water is renewed, and if the barometric pressure has altered since the previous setting, it will also be necessary to readjust the level of the mercury in the U-tube.

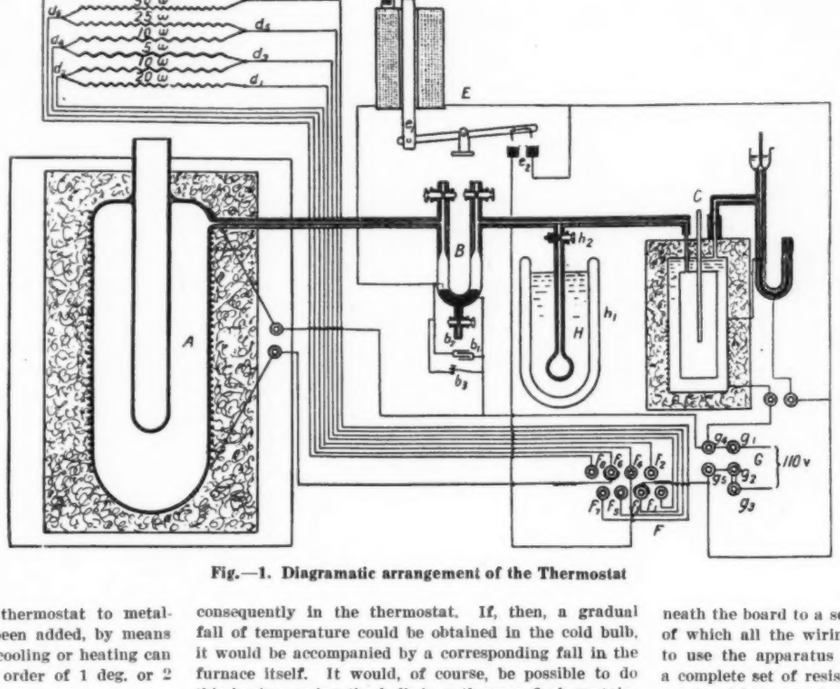


Fig.—1. Diagramatic arrangement of the Thermostat

It is probable that a thermostat of this kind would require little modification to adapt it as a quenching apparatus. If the central tube of A be carried right through the air bulb, and be left open at both ends, the furnace could be used in the same manner as an ordinary wire-bound tube furnace, or as a Rosenhaim vacuum quenching furnace.

In an instrument of this kind the electrical connections tend to become very numerous, and it has been found very convenient to mount the whole on a large wooden base, the connecting wires being led underneath the board to a set of terminals in front, by means of which all the wiring is controlled. If it is desired to use the apparatus for high and low temperatures, a complete set of resistances should be included, which can be picked out at will by two loose leads, the whole arrangement being illustrated in diagrammatic form in Fig. 1. Such an apparatus can be designed to work on a single voltage. A photograph is reproduced in Fig. 2.

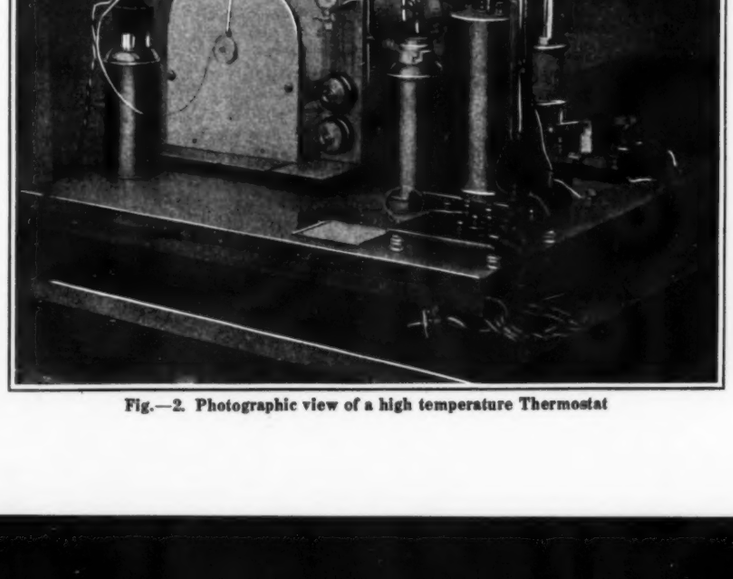


Fig.—2. Photographic view of a high temperature Thermostat

*Institute of Metals.—Abridged in *The Engineer*.

[1] *Journal* of the Institute of Metals, No. 2, 1915, vol. xiv, pages 145-149.

Electric Power in Relieving Coal Shortage

Now that the question of coal shortage has been brought so prominently to the attention of the public by the recent closing order of the fuel administrator, it is interesting to note the splendid work being done and savings effected by the railroads that have adopted electricity as a motive power on a part of their lines.

On the Elkhorn grade electrification of the Norfolk & Western Ry., which is one of the biggest coal carrying roads in the country, the 270-ton Baldwin-Westinghouse electric locomotives haul a 3250-ton train of steel cars loaded with coal, en route for eastern points. Previous to the electrification it required three of the biggest modern type of Mallet locomotives equipped with mechanical stokers to haul a train of this tonnage up the Elkhorn grade at a speed of seven miles an hour. Now two electric locomotives haul it up the same grade at 14 miles per hour or double the speed formerly obtained by the steam locomotives. As a matter of fact, in cold weather it was frequently necessary to reduce the tonnage of the train considerably in order to permit the steam locomotives to get it up grade. With electric propulsion, the same coal traffic can, therefore be hauled with about one-third the former number of locomotives.—*Railway Review*.

Developments in Alternating-Current Work—I*

The Technical Story of the Frequencies

By B. G. Lamme

THE story of how and why the various commercial frequencies came into use and then dropped out again, in most cases, is not primarily the story of the frequencies themselves, but of the various uses to which the alternating current has been applied.[1] In other words, fundamental changes in the application of alternating current have led to radical changes in the frequencies. Some of the applications which have had a determining factor on the frequency of the supply system are as follows; incandescent lighting, transformers, transmission systems, arc lighting, induction motors, synchronous converters, constructional conditions in rotating machinery and operating conditions. A brief consideration of these items individually, from the present viewpoint, indicates that while some of them had, at one time, very considerable influence in determining frequency conditions, yet, in a number of cases, the original reasons have disappeared through improvements and refinements, as will be described later.

At various times the following standard frequencies have been in use in this country, namely, 133⅓, 125, 83⅓, 66⅔, 60, 50, 40, 30 and 25 cycles per second. These did not appear chronologically in the order given above, and a few odd frequencies in a few special applications are omitted.

In the following, the various frequencies will be considered more or less in the order of their development and basic reasons will be given for their choice, and the writer will endeavor to show why certain of them have persisted, while others have dropped out. It will also be shown why the commercial situation has first tended strongly toward certain frequencies and afterwards swung toward others.

133 AND 125 CYCLES

In the earliest alternating work, the whole service consisted of incandescent lighting, and the electric equipment was made up of small high-speed belted single-phase generators and house-to-house distributing transformers. As the transformers were of small capacity and as their design was in a very crude state, it was believed that a relatively high frequency would best meet the transformer conditions. A choice of such an odd frequency as 133⅓ cycles per second, is due to the fact that in those early days (1886 to 1893) frequencies were usually designated in terms of alternations per minute. One of the earliest commercial generating units constructed by the Westinghouse company had a speed of 2,000 revolutions per minute and had eight poles. This presented a fairly convenient constructional arrangement for the surface-wound type of rotating armature, which was the only one recognized at that time. The speed of 2,000 revolutions per minute, with eight poles, gave 16,000 alterations per minute, or 133⅓ cycles per second according to our present method of designation. Thus the earliest frequency in commercial use in this country was fixed, to a certain extent, by constructional reasons, although the house-to-house transformer problem apparently indicated the need for a relatively high frequency. The Thomson-Houston company adopted a standard frequency of 15,000 alternations per minute (125 cycles) instead of the Westinghouse 16,000, but the writer does not know why this difference was made. However, the two frequencies were so close together that practically they could be classified as one.

At this time, it should be borne in mind, there were no real transmission problems, no alternating-current arc lighting, no induction motors and the need for uniform rotation of the generators was not recognized. The induction motor, in its earliest stages, came in 1888 and considerable work was done on it in 1889 and 1890, but it required polyphase supply circuits and comparatively low frequency and, therefore, it has no connection whatever with the then standard single-phase, 133⅓ and 125 cycle systems. The synchronous converter was also unheard of (one might say almost undreamed of) at that time.

60 CYCLES

In 1889 or 1890 it was beginning to be recognized in this country that some lower frequency than 125 and 133⅓ cycles would be desirable. Also about this time direct-coupled and engine-type alternators were being considered in Europe and it was felt that such construction would eventually come into use in America. It was appreciated that in such case, 133⅓ cycles would present very considerable difficulties compared with some much lower frequency, due to the large number of poles which would be required. For instance, an alternator direct driven by an 80-revolution per minute engine would require 200 poles to give the required frequency and such construction was looked upon as being practically prohibitive. About this time Mr. L. B. Stillwell, then with the Westinghouse company, made a very careful study of this matter of a new frequency, in connection with the possibilities of engine type generators, and after analyzing a number of cases, it appeared that 7,200 alternations per minute (60 cycles per second), was about as high as would be desirable for the various engine speeds then in sight. Transformer constructions and arc lighting were also considered in this analysis. While it was deemed that a somewhat higher frequency might be better for transformers, yet a lower frequency than 60 cycles was considered as possibly better for engine type generators. A compromise between all the various conditions eventually led to 60 cycles as the best frequency. However, while this frequency originated about 1890, it did not come into use suddenly, for it was impossible to introduce such a radical change in a brief time. Moreover, the direct-coupled or engine-type generator was slow in coming into general use and, therefore, there was not the necessity for the introduction of this low frequency in many of the equipments sold from 1890 to 1892. However, by 1893, 60 cycles became pretty firmly established and was sharing the business with the 133⅓-cycle systems. It should be borne in mind that, at this time, the adoption of this frequency was not considered as a direct means for bringing forward the polyphase induction motor, for the earlier 60-cycle systems, like the 125- and 133⅓-cycle, were all single-phase. Also it was then thought that the polyphase motor would possibly require a still lower frequency and, moreover, the polyphase system was looked upon as in a class by itself, suitable only for induction motor work. At that time the introduction of polyphase generators for general service was not contemplated. This followed about two or three years later.

In 1890 the Westinghouse company, which had been developing the Tesla polyphase motor, laid aside the work, largely on account of there being no suitable general supply systems for this type of motor. The problem was again revived in 1892, in an experimental way, with a view to bringing out an induction motor which might be applied to standard frequencies such as could be used in commercial supply circuits for lighting and other purposes. It should be understood that at this time such circuits were not in existence but were being contemplated. In 1893, after the polyphase motor had been further developed up to the point where it showed great commercial possibilities, the best means for getting it on the market were carefully considered. It was decided that the best way to promote the induction motor business was to create a demand for it on commercial alternating-current systems. This meant that, in the first place, such systems must be created. Therefore, it was decided to undertake to fill the country with polyphase generating systems, which were primarily to be used for the usual lighting service. It was thought that, with such systems available, the time would soon come when there would be a call for induction motors. In this way experience would be obtained in the construction and operation of polyphase generators and the operating public would not be unduly handicapped in the use of such generators, compared with the older single-phase types.

An early example of this new practice was in the 2,000-kw. polyphase generating units used for lighting the Chicago World's Fair in 1893. Here the single-phase type still persisted, as each generator unit was made up of two similar frames placed side by side, but with their single phase armatures displaced one-half pole pitch from each other so that the combined machine delivered two single-phase currents displaced 90 degrees from each other. It was considered that each circuit could be regulated independently for lighting service, and polyphase motors could be operated from two circuits. These generators (at that time the largest in this country) were designed in 1892 and were of 60 cycles. These, therefore, indicate the tendency at that time toward lower frequency and polyphase generation, although commercial polyphase motors were not yet on the market.

At the same time that 60 cycles was selected as a new standard it was recognized that at some future time there would be a place for some much lower frequency, but it was not until two years later that this began to narrow down to any particular frequency. In 1892 the first Niagara electrification, after several years consideration by eminent authorities, had centered on polyphase alternating current as the most desirable system. The engineers of the promoting company had also worked out what they considered the most suitable construction of machine. This involved 5,000 h. p. units at 250 revolutions per minute. Prof. George Forbes, one of the engineers of the company, had furnished the electrical designs for a machine with an external rotating field and an internal stationary armature. His design used eight poles, thus giving 2,000 alterations per minute, or 16⅔ cycles per second. Quite independently of this, the Westinghouse company, in 1892, had been working on the development of synchronous converters, using belted 550-volt d-c. generators with two-phase collector rings added. The tests on these machines had shown the practicability of such conversion and had even proved at this early date that the converter copper losses were much lower than in the corresponding d-c. generators. Thus it is an interesting fact that the first evidence of this important principle was obtained from a shop test rather than by calculation. The writer, from an analysis of the tests, which were made under his immediate direction, concluded that the armature copper losses must be considerably lower than in the same machine used as a d-c. generator. He also brought the matter to the attention of Mr. R. D. Mershon, then with the Westinghouse company, and the problem was then worked out mathematically by him and the writer, in two quite different ways, but with similar results, showing that the converter did have actually very much reduced copper losses.

As a result of this work of the Westinghouse company on the synchronous converter, it was decided that, to make such machines practicable, some suitable relatively low frequency was required. This appeared to be about 30 cycles. About this time the construction of the Niagara generators was taken up with the Westinghouse company to see whether it would construct these machines according to the designs submitted by the promoting company's engineers. These designs were gone over as carefully as the knowledge of such apparatus, at that time, permitted, and many apparent defects and difficulties were pointed out. The Westinghouse company then proposed, as a substitute, a 16-pole, 250-rev. per min. machine (the speed being definitely fixed at 250 rev. per min.). This gave 33⅓ cycles, or as near to the Westinghouse proposed 30-cycle system as it was possible to get. Then many arguments were brought forward, pro and con, for the two machines and frequencies. Prof. Forbes' preference for 16⅔ cycles was based partly on the possibilities it presented for the construction and operation of commutator type motors, just as with direct current circuits. The Westinghouse contention was that this frequency was too low for any kind of service except possibly commutator type machines. Tests were made with incandescent lights and it was found that at 33⅓ cycles there was little or no winking of light, while at 16⅔ cycles the winking was extremely bad. Tables were also made up, showing the limited number of speed combinations at 16⅔ cycles for induction motors, in case such should come into use. This showed how superior the 33⅓ cycles would be as regards such apparatus. It was also brought out that synchronous converters, when such became commercial, would be much better adapted for the higher frequency, as the choice of speeds would be much greater. From the present viewpoint the arguments appear to have been much in favor of the Westinghouse side of the case.

As a consequence of all this discussion the suggestion was advanced by someone that a 12-pole, 250-revolution machine (that is, 3,000 alternations, or 25 cycles), might meet sufficiently the good qualities of both of the pro-

*Presented at the Section Meeting of the American Institute of Electrical Engineers, Washington, Jan. 18, and republished by permission from the *Proceedings* of the Institute.

[1]It should be distinctly understood that this paper covers only the story of American development.

posed frequencies and would thus be a good compromise. In consequence a 12-pole, 25-cycle machine was worked up by the Westinghouse company and eventually this frequency was adopted for the Niagara generators. Afterwards, while these generators were being constructed, it was brought out pretty strongly that the great advantage of this frequency would be in connection with synchronous converter operation, but that it was also extremely well adapted for slow-speed engine type generators, which were then coming into use. In consequence of the prominence given this frequency it was soon adopted as a standard low frequency, especially in those plants where synchronous converters were expected to form a prominent part of the system.

However, while 60 and 25 cycles came into use, as described above, it must be recognized that they had competitors. For instance, 66⅔ cycles (8,000 alternations or one-half of 16,000) was used to a considerable extent by one of the manufacturing companies. Also 50 cycles came into use in certain plants and, to a certain extent, is still retained, but has become the standard high frequency of Europe. Instead of 25 cycles, the Westinghouse company advocated 30 cycles for some of its plants, largely because with the 25 per cent. higher speeds permissible with such frequencies, the capacities of induction motors could be correspondingly increased and also incandescent lighting was more satisfactory. However, it was soon recognized that the 66⅔ and 30 cycle variations from the two leading frequencies of 60 and 25 cycles were hardly worth while, and they were gradually dropped, except in plants already installed. A brief attempt was made at a somewhat later period to place 40 cycles upon the market as a substitute for both 25 and 60 cycles. This was done under the impression that 40 cycles would give a universal system for arc and incandescent lighting, transmission, induction motors, synchronous converters and about everything else. This frequency possessed many merits and it was thought, at one time, that it might win out, but apparently the other two frequencies were too well established, and the 40-cycle system eventually lost ground.

The problem of the frequencies finally narrowed down to the two standards, and these two were accepted because it was thought that they covered such entirely different fields of service that neither of them could ever expect to cover the whole. In other words, two standards were required to cover the whole range of service. It was recognized that 25 cycles would not take care of alternating-current arc lighting and that it was questionable for incandescent lighting in general. In other ways, such as suitability for engine-type construction, application to induction motors and synchronous converters and transmission of power to long distances, it met the needs of an ideal system, as then understood. Also, in parallel operations of engine-type alternators, which was one of the serious problems of those days, the 25-cycle machines were unquestionably superior to the 60-cycle ones, due to the lesser displacement of the e. m. f. waves with respect to each other with a given angular variation in the engine speeds. However, although the 25-cycle system presented so many advantages, it could not take care of the lighting business, and, therefore, could not entirely dominate the situation.

As regards 60 cycles, it was felt that this could handle the direct lighting situation in a very satisfactory manner and was possibly better suited for transformers than 25 cycles, although there were differences of opinion in this matter, especially when it came to the larger capacities. It was reasonably well adapted for induction motors in general, but not for very low speeds. In matters of transmission and in the operation of synchronous converters it was thought to be vitally defective.

From the above consideration it would appear that the 25-cycle systems presented the stronger showing as a whole and, therefore, there was a decided tendency toward this frequency, except in those cases where lighting directly from the alternating-current system was considered of prime importance. In those systems, such as many of the Edison companies, where low-voltage three-wire direct current was used from synchronous converters, the tendency was almost solidly toward the 25-cycle system. In those days the central station, which had gotten itself committed to the 60-cycle system so deeply that it could not change, was looked upon with commiseration. Sixty-cycle plants were looked upon, to a certain extent, as a necessary evil. In fact, so strong was the tendency toward 25 cycles that in many cases 25-cycle plants were installed for industrial purposes, where 60 cycles would have been better. The 25-cycle synchronous converter development advanced by leaps and bounds and the machines were so good in their operation that it was believed that 60-cycle converters could never be really competitive with them.

On the other hand, in those large plants, which were so "unfortunate" as to have 60 cycles installed, many apparent makeshifts were adopted to meet the various service requirements. In arc lighting, incandescent lighting, transformers and motors there was no need for makeshifts. However, in conversion to direct current, one of the greatest difficulties appeared. There were many who advocated motor-generators for this purpose, largely because the 60-cycle converter was thought to be impracticable, in spite of the fact that the manufacturing companies were putting them on the market. The 60-cycle converter at that time bore a bad name. It is now recognized that many of the faults of the early 60-cycle synchronous converter operation were not in the converters themselves, but were, to a considerable extent, in the associated apparatus. Low-speed engine-type, 60-cycle generators were not always adapted for operation of synchronous converters. In fact, in numerous cases such generators would not operate in an entirely satisfactory manner in parallel with each other, and yet when it was attempted to operate synchronous converters from these same generators the unsatisfactory results were not blamed upon the generating system but upon defects of the converters themselves. Unfortunately, defects in the generating and transmission systems usually appeared in the converters as sparking and flashing, and such troubles naturally would be credited to defects in the construction of the converters themselves. In fact, in those days, 60-cycle converters were expected to do things which now are considered as absurd. For instance, in one case in the writer's knowledge a 60-cycle synchronous converter was criticized as being a very badly designed piece of apparatus, due to serious flashing at times. Investigation developed that this converter was expected to operate on either one of two independent 60-cycle systems with no rigid frequency relation to each other. The converter in service was thrown from one system to the other indiscriminately, and sometimes it flashed in the transfer and sometimes it did not. The machine was considered to be "no good" because it would not always stand such switching.

At one time the writer stood almost alone in his belief that the 60-cycle synchronous converter presented commercial possibilities sufficient to make it a strong future contender with the 25-cycle machine, provided proper supply conditions were furnished and certain difficulties in the proportions of the converter itself were overcome. One basis for this contention was that in some of the 60-cycle plants, where the generator rotation was quite uniform, the converters were evidently much superior in their operation to other plants, using slow-speed engine-type generators with considerable periodic variations. In such plants the hunting tendency of the converters was very greatly reduced, with consequent improvement in sparking and general operation. It was early recognized that hunting was a very harmful condition, both in 60 and 25-cycle synchronous converters, but whereas it was a relatively rare condition in 25-cycle plants it was much more common with 60 cycles. However, the operating public was not particularly concerned whether the trouble was in the generating plant or in the converters themselves, as long as such trouble existed and was not overcome. Very early in the synchronous converters development it was found that hunting would produce sparking or flashing at the commutators of the converters. However, even in those plants where there was no hunting apparent, there was difficulty at times due to flashing, especially with sudden change of load, which resulted in temporary increase in the d-c. voltage. This was a difficulty which was inherent in the converter itself and could not be blamed entirely upon the generating or transmitting conditions, for 25-cycle machines were practically free from this trouble under similar conditions of operation. Investigation developed the fact that this flashing trouble was due largely to unduly high value of the maximum volts between commutator bars. This difficulty was recognized long before it was overcome, simply because certain physical limitations in construction had to be removed. There were two ways in which the maximum volts per bar could be reduced, namely, by increasing the number of commutator bars per pole and by decreasing the ratio of the maximum volts to the average volts per bar, that is, by increasing the ratio of the pole width to the pole pitch, but both of these involved structural limitations in the allowable peripheral speeds of the commutator and the armature core. Here is where a little elementary mathematics comes in. The peripheral speed of the commutator is directly proportional to the distance between adjacent neutral points on the commutator, and the frequency. Therefore, with a given frequency the distance between the adjacent neutral points is directly proportional to the peripheral speed. Thus, a commutator speed of 4,500 feet per minute which was then considered an upper limit, the distance between adjacent neutral points on a 60-cycle converter is only 7½ inches (19 cm.). This distance is thus fixed mathematically and is independent of the number of poles or revolutions per minute, or anything else, except the peripheral speed and the frequency. With this distance of 7½ inches (19 cm.), about the only choice in commutator bars per pole was 36, giving an average of 16⅔ volts per bar on a 600-volt machine, and nearly 20 volts per bar with momentary increase of voltage to 700, which is not uncommon in railway service.

However, it is not this average voltage which fixes the flashing conditions, but it is the maximum voltage between bars, and this is dependent upon the average voltage and upon the ratio of the pole width to the pole pitch. Here is where one of the serious difficulties came in. As mentioned above, the pole pitch is directly dependent upon the peripheral speed of the armature core and the frequency. Therefore, in a 60-cycle machine, if the peripheral speed is fixed, the pole pitch is at once fixed. For example, with an armature peripheral speed of 7,200 feet per minute, which was considered high at the time, the pole pitch becomes 12 inches (30.48 cm.), regardless of any other considerations, and here was where a most serious difficulty was encountered. If a sufficiently wide neutral zone for commutation was allowed the interpolar space became so wide that there was not enough left for a good pole width. For instance, if the interpolar space was made 6 inches (15.24 cm.) wide, in order to give a sufficiently wide commutating zone to prevent sparking or flashing, due to fringing of the main field, then this left only 6 inches for the pole face. With this relatively narrow pole face the ratio of the maximum volts to the average volts was so high that with the 36 commutator bars per pole the machine was sensitive to arcing between commutator bars, thus resulting in flashing. By widening the pole face this difficulty would be lessened or overcome, but with the fixed pole pitch of 12 inches (30.48 cm.) the neutral zone would be so narrowed as to make the machine sensitive to sparking and flashing at the brushes. Thus, no matter which way we turned we encountered trouble. Obviously there were two directions of improvement, namely, by increasing the number of commutator bars, thus reducing the average voltage, and by increasing the pole pitch, thus allowing relatively wider poles with a given interpolar space. These two conditions look simple and easy, but it took several years of experience to attain them. When we have reached apparent physical limitations in a given construction, especially when such limitations are based upon long experience, we have to feel our way quite slowly toward higher limitations. For instance, in the case of the 60-cycle converters we could not boldly jump our peripheral speeds 20 to 25 per cent. higher and simply assume that everything was all right. We first had to build apparatus and try it out for a year or so. Troubles, due to peripheral speed, do not always become apparent at once, and thus time tests are necessary. Therefore, while the peripheral speeds of the 60-cycle synchronous converters were actually increased 20 to 25 per cent. practically in one jump, yet it took two or three years of experimentation and endurance tests before the manufacturers felt sure enough to adopt the higher speeds on a broad commercial scale. Thus, while the change from the older more sensitive type of 60-cycle converter to the later type occurred commercially within a comparatively short period, yet the actual development covered a much longer period.

[TO BE CONTINUED]

Birds Used in Falconry

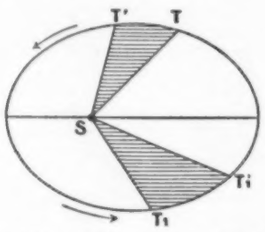
AN exhibit of birds used in falconry, in the American Museum, is attracting the attention of those interested in mediæval practices. The birds in the exhibit range from the small hobby falcon, used by the young squires in the pursuit of small game to the large goldeneagle, capable of carrying away a small mountain goat. The taming and training of birds of prey for sport was practised in China as early as 400 B. C., and although it was not introduced into Europe until much later, it had become the usual custom in western Europe and England by the end of the ninth century. In the language of falconry the term "falcon" was applied only to the females; the males, which were about one third smaller, being called "tiercels." In Shakespeare's time everyone who could afford to do so kept a hawk, and the rank of the owner was indicated by the species of bird he carried. To a king belonged the gerfalcon; to a prince, the falcon gentle; to an earl, the peregrine; to a lady, the merlin; to a young squire, the hobby.—*The Amer. Museum Journal.*

Attraction Between Two and Three Bodies*

By G. Boucheny

THE *problem of two bodies.* The system of Copernicus, announced in 1543, in his work *De Berolutionibus Orbium Caelstium* (libri VI), was destined to prove very fecund. First came the laws of Kepler published in 1609, which completed it so happily. These are as follows:

1. *Every planet describes around the sun, traveling*



towards the right, an ellipse one of whose foci is occupied by the sun.

2. *The areas described by the vector radius which joins the center of the sun with the center of the planet are proportional to the times required to describe them.*

Thus the earth having required a time t to pass from the position T to the position T' and a time t' to pass from the position T_1 to the position T_1', S being the center of the sun we have the ratio:

$$\frac{\text{Area T S T'}}{\text{Area T}_1\,\text{S T}_1'} = \frac{t}{t'}$$

In particular, for equal times, the areas described by the vector radius S T are equal.

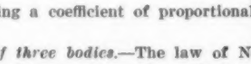
3. *The squares of the times of the siderial revolutions of two planets are proportional to the cubes of the great axes of their orbits.*

If we consider two planets accomplishing their revolutions in the times t and t', the ellipses which they describe around the sun having respectively the great axes whose measures are A and A', the third law of Kepler gives the ratio:

$$\frac{t^2}{t'^2} = \frac{A^3}{A'^3}$$

The trajectories described by the planets being known, as well as the laws of their movements, Newton undertook the investigation of the forces producing these movements, and found that the sun attracts each planet proportionally to its mass and in inverse ratio to the square of its distance. He did not stop here, but proceeded to enunciate the "principle of universal gravitation": *Any two molecules whatever attract each other, and the force which draws one towards the other is proportional to their masses and in inverse ratio to the square of their distance.*

O and O' being the two molecules, d their distance, m and m' their masses, O is attracted to O', and inversely; the forces of attraction are directed accord-



ing to the straight line OO', and their intensity equals

$f \frac{mm}{d^2}$, f being a coefficient of proportionality.

Problem of three bodies.—The law of Newton gave the solution of the problem of two bodies; in reality this problem does not present itself in astronomy; it is *the problem of n bodies* which demands solution. In other words, if we accept Newton's law we find ourselves confronted by the following general problem:

N material points of known masses occupying definite positions at a given moment, these points having speeds whose magnitude and direction are known, and each two being subjected to the law of universal gravitation, to determine their positions at any given moment. If n=3 we have the problem of three bodies.

Since Newton's time many mathematicians have endeavored to find a general solution of this problem. Clairaut, Euler, d' Alembert, Laplace, Lagrange and later H. Poincaré, have been engaged with it, and yet until recently the problem of three bodies had not been solved except in certain particular cases. In practice approximate solutions have been utilized, which were however, sufficiently exact for the requirements of astronomy; taking as a basis the fact that the planets of the solar system taken together constitute a mass which is only about one seven-hundredth of the mass of the sun, the action of the sun upon a single planet is first considered (problem of two bodies), then corrections of the movement obtained are made, taking into account the perturbing forces resulting from the action of the other planets; the effects of the latter are called *perturbations.* The elements of the planet, calculated according to the problem of the two bodies, are then found to be increased or diminished by quantities which are generally small, and which are termed *inequalities.* On the whole, the successive corrections which one finds it necessary to make give rise to more or less complicated series of developments; in any case, the practical solutions thus discovered do not constitute a true mathematical solution, and the differential equations of the problem of three bodies have remained unsolved. H. Poincaré had discovered particular solutions which are quite remarkable, and without accepting the extreme of Tisserand's radical opinion that the problem is incapable of solution, it seemed probable, after the researches of the eminent French mathematician, that the problem would long continue unsolved.

But this proved to be a mistaken opinion: an astronomer of the Helsingfors Observatory, Mr. Sundmann, offered a complete solution of it, in notes communicated to the Society of Sciences of Finland (Dec. 17, 1906, and Jan. 18, 1909), and finally in a memoir which appeared in Vol. XXXVI of the *Acta Mathematica* in 1912. The Academy of Sciences rewarded this beautiful piece of work by according to Sundmann in 1913 the G. de Pontécoulant prize. Bmile Picard said, in his report to the Academy: "From the point of view of pure analysis we may say that Sundmann's memoir is an epochal work for mathematical astronomers and analysts. Many had believed that the problem of three bodies could not be solved except by means of the previous introduction of very complicated new transcendants. It is not the least of the reader's astonishments to remark with what simplicity the Finnish savant arrived at the solution of so difficult a problem, basing his conclusions solely upon the now classic results in the theory of ordinary differential equations."

*From Larousse Mensuel.

Magnetization and Rontgen-Ray Examination

THE particles of iron and other magnetic substances are supposed themselves to be small magnets which are pointing in all possible directions, as long as the iron is not magnetized, but which arrange themselves in parallel lines under the influence of external magnetic force. With the aid of a group of small magnetic needles, which all turn in the same direction when a strong magnet is approached, the magnetization process can very prettily be illustrated. But this well-known experiment must be regarded merely as an illustration, and not as a demonstration of the actual phenomena. The difficulty is to understand the nature of the ultimate magnetic particles, which are to be turned by magnetic forces, and X-ray examination, which has cleared up some of the difficulties of crystallization phenomena, so far rather appears to complicate the magnetization problem. Most of these researches have been conducted in America. A. H. Forman (*Physical Review*, since 1914), studied the effect of magnetization on the opacity of iron to X-rays. He observed that iron seemed less transparent to penetrating X-rays when magnetized in a direction parallel to the path of the rays than when magnetized at right angles to that direction or when not magnetized. The difference observed was very small, five parts in 3,000, at the best; but he considered that the ultimate magnetic particles were the molecules of iron, and that the plane of maximum absorption of the iron molecule was parallel to that of the electronic orbits which make up the elementary magnet. But A. H. Compton and O. Rognley maintain, that any such orientation of the molecules could only be extremely small. According to Bohr's theory of the atom the magnetic properties would be due to the electrons all lying in the same plane which revolve about the atomic center. Compton does not accept that. In X-ray examination after Bragg, he points out, the intensity of the reflected spectrum line depends upon the distance of the electrons from the middle plane of the atomic layers in the diffracting crystal. When the crystal of iron is not magnetized, the atoms will have their electrons arranged in all possible planes. When the crystal is magnetized at right angles to the reflecting crystal face under examination, the orbits, being at right angles to the magnetic axes of their atoms, would all be driven into the middle plane of the layer of atoms, and this shifting of the atoms would produce an increase in the intensity of the reflected beam. With magnetization parallel to the face, the beam intensity should decrease; but Compton and Rognley did not observe any intensity changes at all. They do not believe in an electron as a point-charge; they deduce from other experiments as well (see *Journal of the Washington Academy of Sciences*, January 4th, 1918), that the different parts of the charge of the electron can possess certain motions independent of one another, and that the distribution of the electrons in the atom is isotropic, *i. e.*, not confined to one plane; the ultimate magnetic particle might then be the electrons themselves, or the atomic nucleus. Somewhat similarly, A. L. Parson had suggested (Smithsonian Institute, Collections, November, 1915), that the atom is made up of a positive nucleus and of magnetons, the latter being ring-shaped negative charges (or electrons). The possibility of a simple explanation of magnetization seems to be very remote.—*Engineering.*

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